

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

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FM systems Versus Directional Microphone

HAs:

- ⦿ FM only – 12-15 dB improvement if microphone at the location of the talker
- ⦿ FM with environmental microphone or less optimal microphone location ~ 3-5 dB improvement (e.g. (Hawkins, 1984; Fabry, 1994; Crandell & Smaldino, 2000; Lewis et al, 2004)



- Clearly FM works - However, there are multiple school environments for which FM technology may not be optimal or desirable – but communication remains important
- Directional microphone – 2-4 dB improvement when speech is front and relatively near, noise surrounds (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; Ricketts, et al., 2008; Valente et al, 2000; Voss 1997; Wouters, et al, 1999)

Phase 1 and 2: Potential For Directional Benefit?

- Children (11-17 yo – n = 26) demonstrate a 2.5-3.5 dB directional benefit when the speech source is front and a 2-3 dB directional decrement when the speech source is behind in simulated classroom environments (Ricketts, et al., 2008).
 - Directional advantage in some noisy environments and disadvantage in others provides additional support that full time directional use is NOT appropriate, **even in noise**.
- Final recommendation for directional HA use in school aged children is dependent on ensuring the optimal microphone mode and ensuring appropriate head orientation.



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

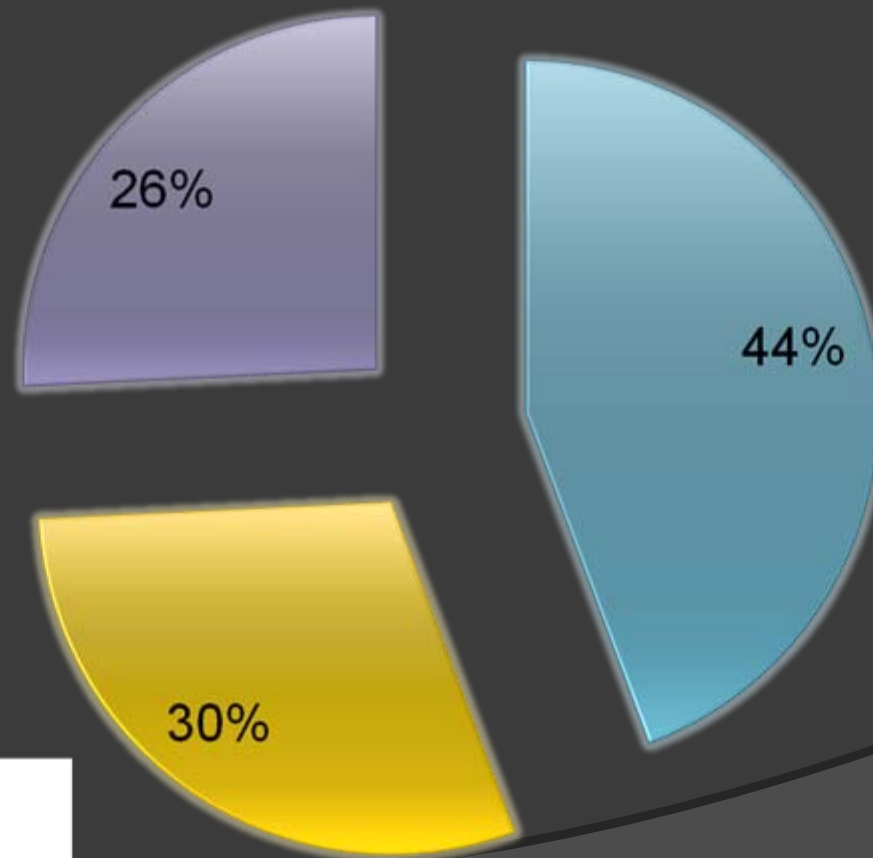
- How often and in what school environments is the directional mode really appropriate?
- What is the best way to ensure the correct microphone mode (dir/omni)?

Linking Optimal Microphone Mode to School Setting: 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.

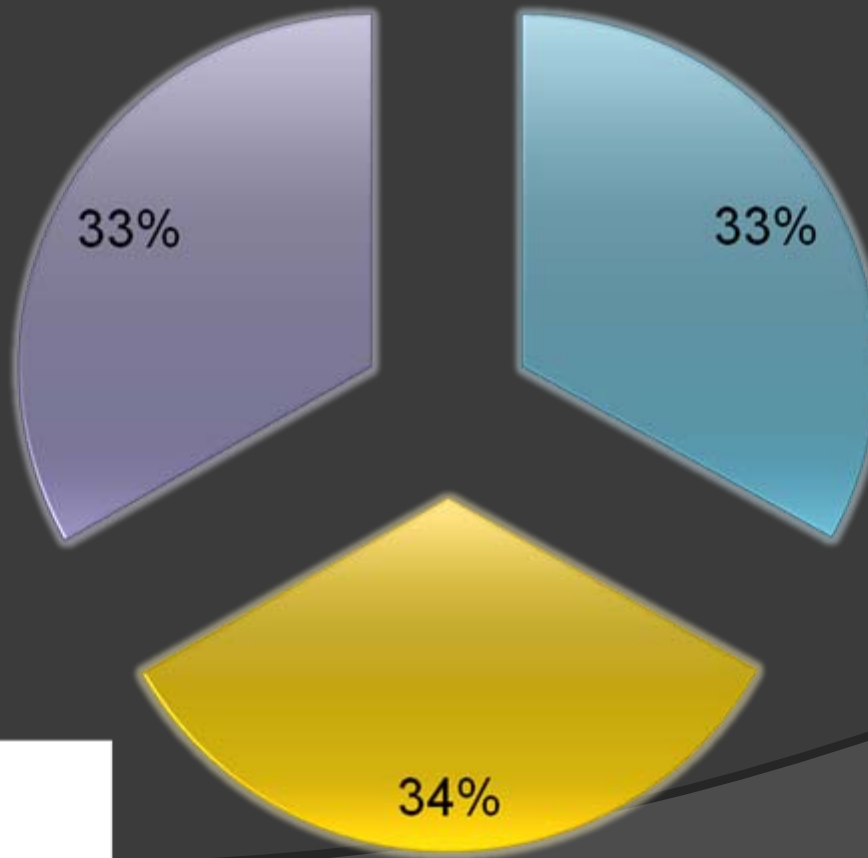
Portion of a Six Hour School Day (Observer Opinion) – Average (5-10 yo)



- Omni
- Directional
- Either (Quiet/No Talker)

◎ Number of switches in one class period ranged from 0 to 22.

Portion of a Six Hour School Day (Observer Opinion) – Average (11-17 yo)



◎ More quiet time and less group interaction for the older kids

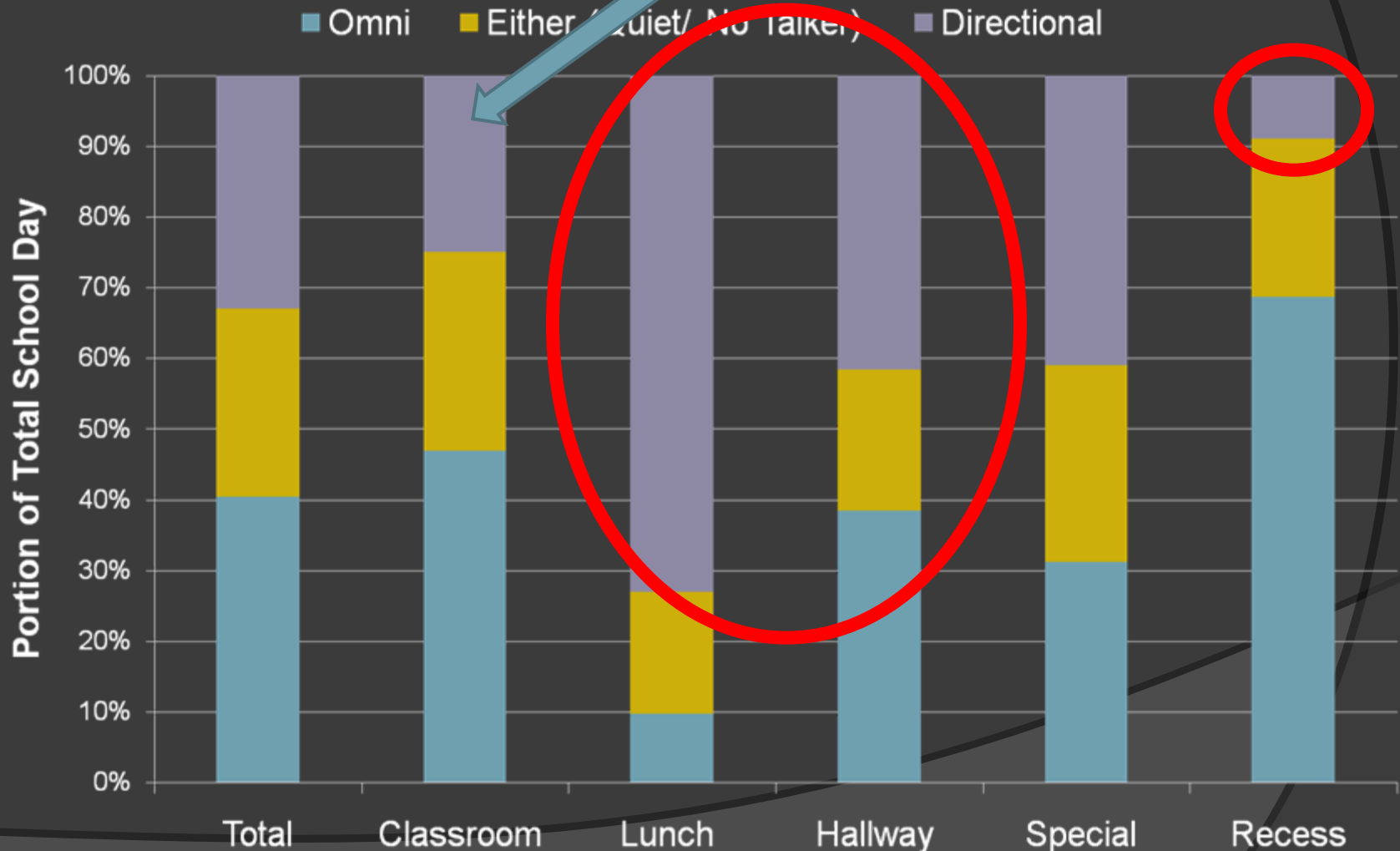
- Omni
- Directional
- Either (Quiet/No Talker)

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 (8-70%).

Type of Environment? (Averaged Data)

Somewhat limited opportunities:
implications for overhearing?



**SO HOW DO WE
ENSURE THE
OPTIMAL
MICROPHONE MODE?**

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?

Results from 24 Children: Agreement in the Manual Mode

- ⦿ Sixteen participants never left the omnidirectional mode
 - Other than to show the observer they could
- ⦿ Three 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.

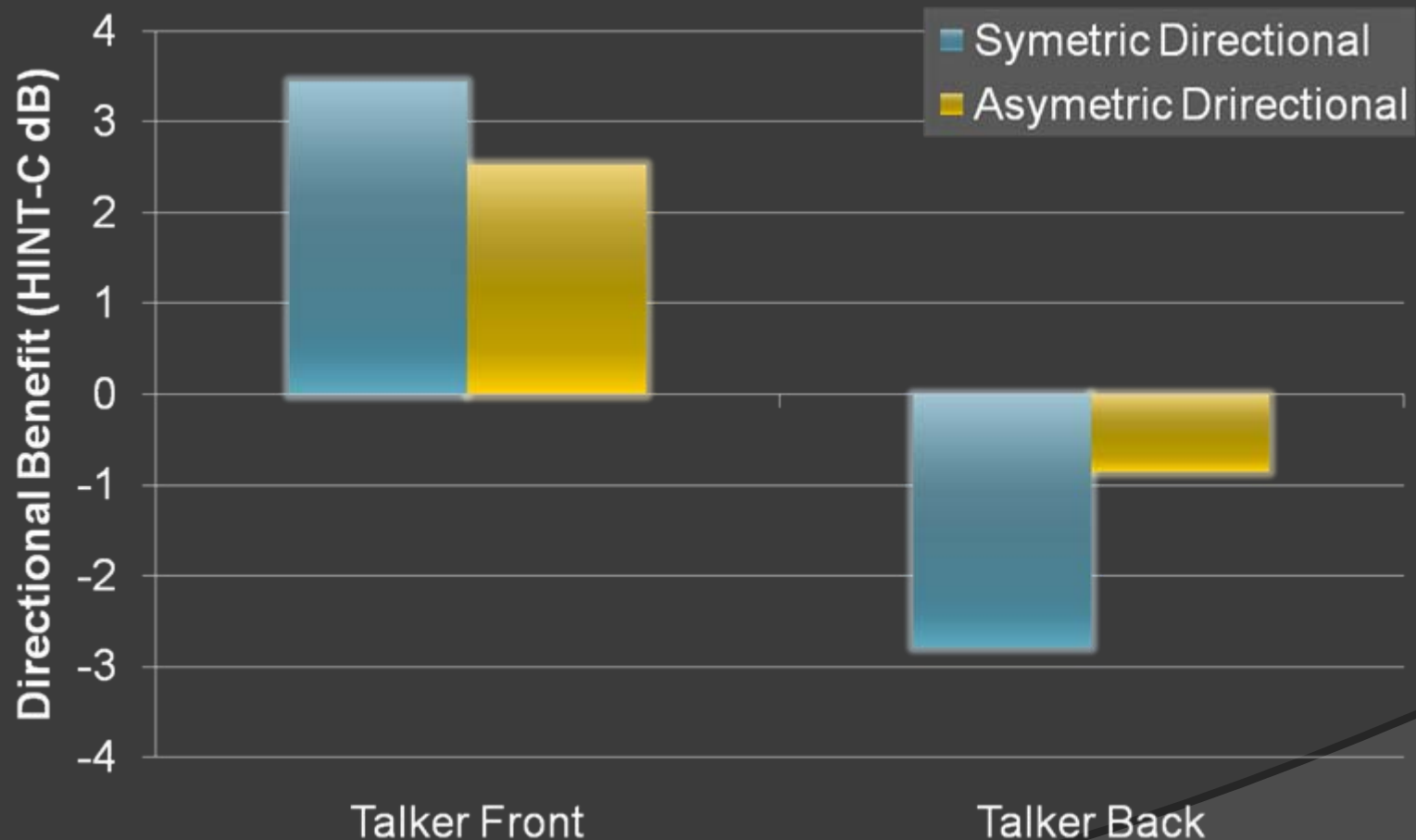
Asymmetric Fitting:
O/D or D/O



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

New Data: Directional Benefit in a Simulated Classroom (N = 15)



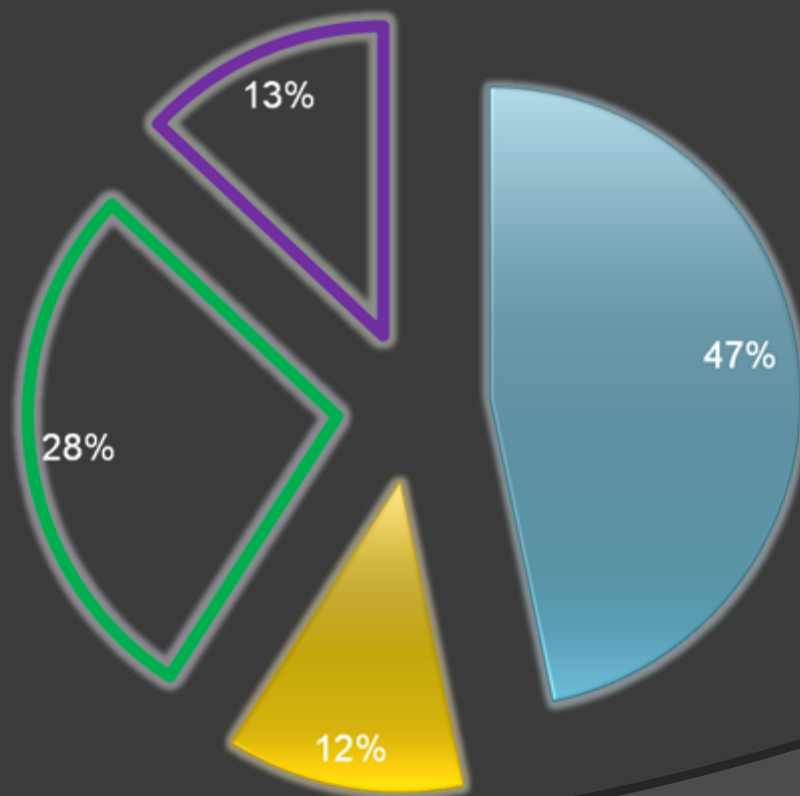
Clinical Implications

- May be some interesting automatic applications for asymmetric
- 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?**

Agreement in Automatic Mode (5-10 yo) N = 14

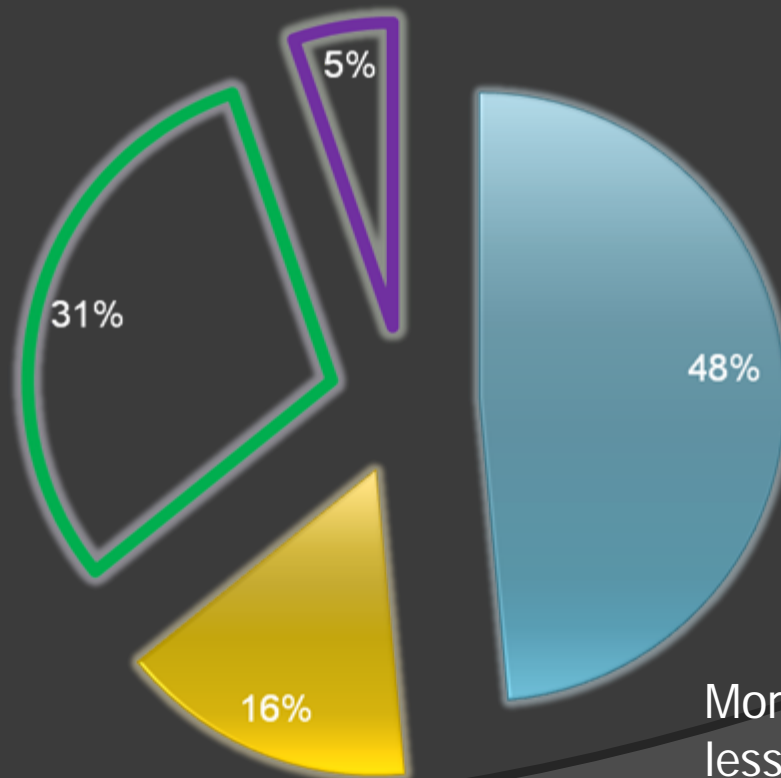
■ Agree - O ■ Agree - D ■ HA-O/Obs-D ■ HA-D/Obs-O



Only in active listening situations in noise ("No Talker" and "Quiet" not considered)

Agreement in Automatic Mode (11-17 yo) N = 10

■ Agree - O ■ Agree - D ■ HA-O/Obs-D ■ HA-D/Obs-O



More Directional Agreement,
less HA-D/Obs-O than in
Younger Children

HA – O, Observer – D (~30% Error rate) :

Why were mistakes made?

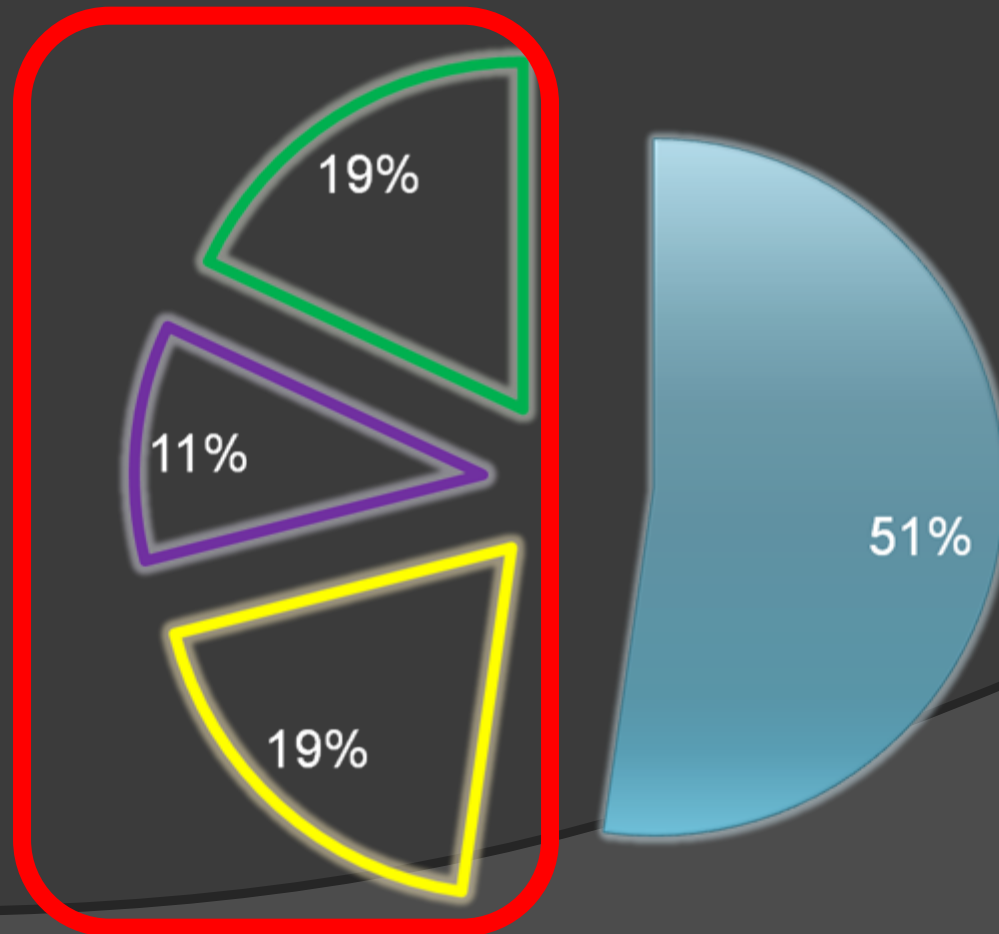
- ⦿ Main talker position, always front
- ⦿ Noise from various angles (commonly back and surround)
- ⦿ Noise and reverberation levels moderate
- ⦿ Hearing Aid Classifier – Highest probability of speech in quiet in 22 of 24 cases.
- ⦿ Conclusion: The few distracting talkers/ low level noise mis- quantified as signals of interest.
 - To be correct the hearing aid would have to switch more aggressively (especially for softer input levels).

HA – D, Observer – O (5 -13% Error rate): 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 in all 24 cases.
- ⦿ Main noise and talker position?

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

■ Front ■ Side ■ Back ■ Multiple



49% of the time the error resulted from not accounting for overhearing

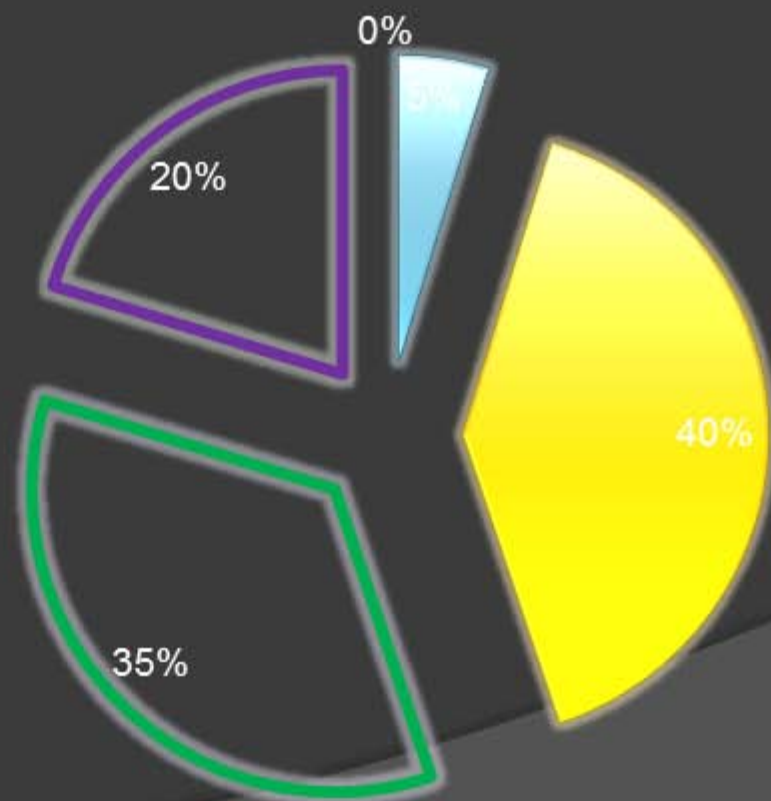
Is there a fix?

HA – D, Observer – O: Noise Position When Talker Was in Front

■ Back ■ Surround ■ Front ■ Side ■ None

At least 35% of the time when overhearing was not the problem - whether it was directional or omni probably didn't matter

Except for possible monitoring



Automatic Switching Accuracy: The Bottom Line?

- Accuracy is moderate to good overall, but perhaps this particular system could be made slightly more aggressive for school settings by lowering the activation threshold.
- To correct the majority of mistakes the hearing aid would have to know the listeners intent

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.

This only occurred in 5 -13% of active listening situations – but how important are those situations to learning – particularly social learning?

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).

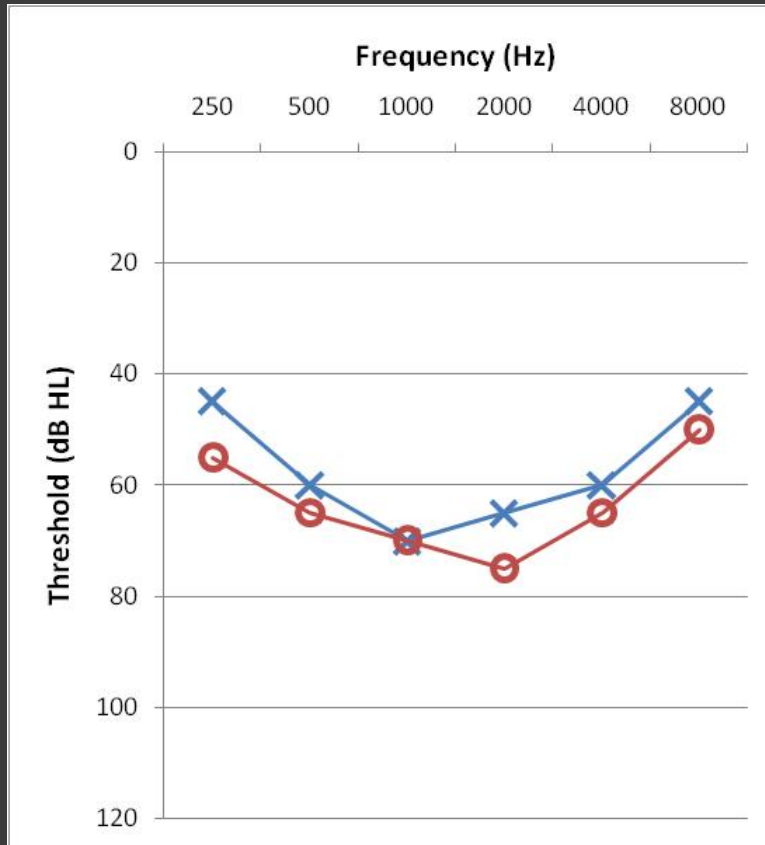
A Little Indirect Evidence that Overhearing is Important To Listeners – After 1 Month Trials (Ricketts et al., 2008)

- ⦿ 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?

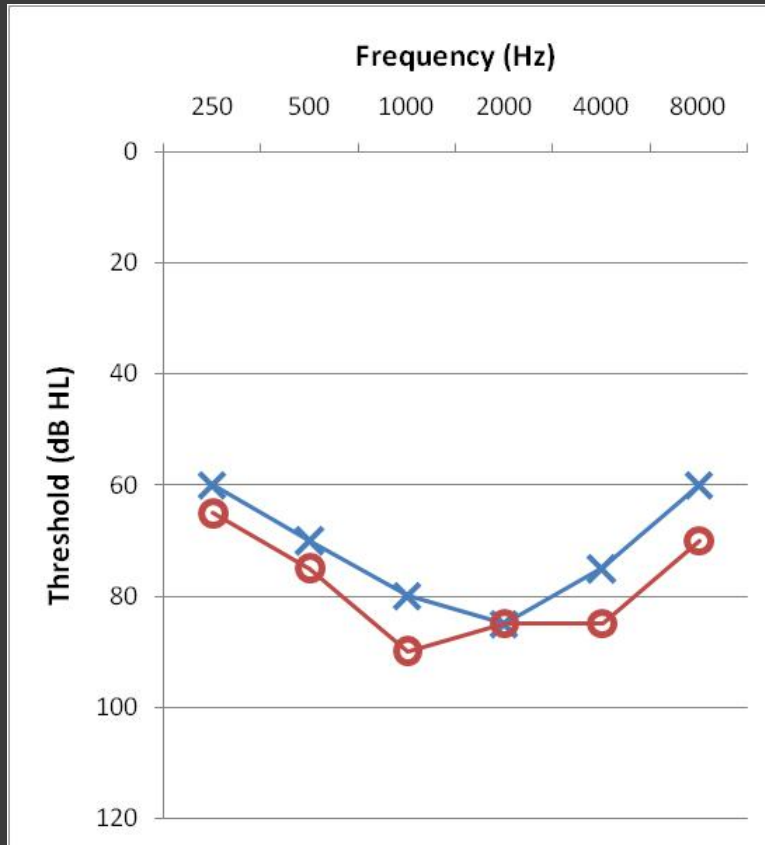
- ⦿ Given the negative reaction to “directional deficits” occurring in noise we recommend...
- ⦿ Automatic directional in program 1, **OMNI** in program 2
 - Instruct to go to program 2 “if you are having difficulty hearing someone who is not in front of you”
- ⦿ But this doesn't always work!
 - A few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

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)

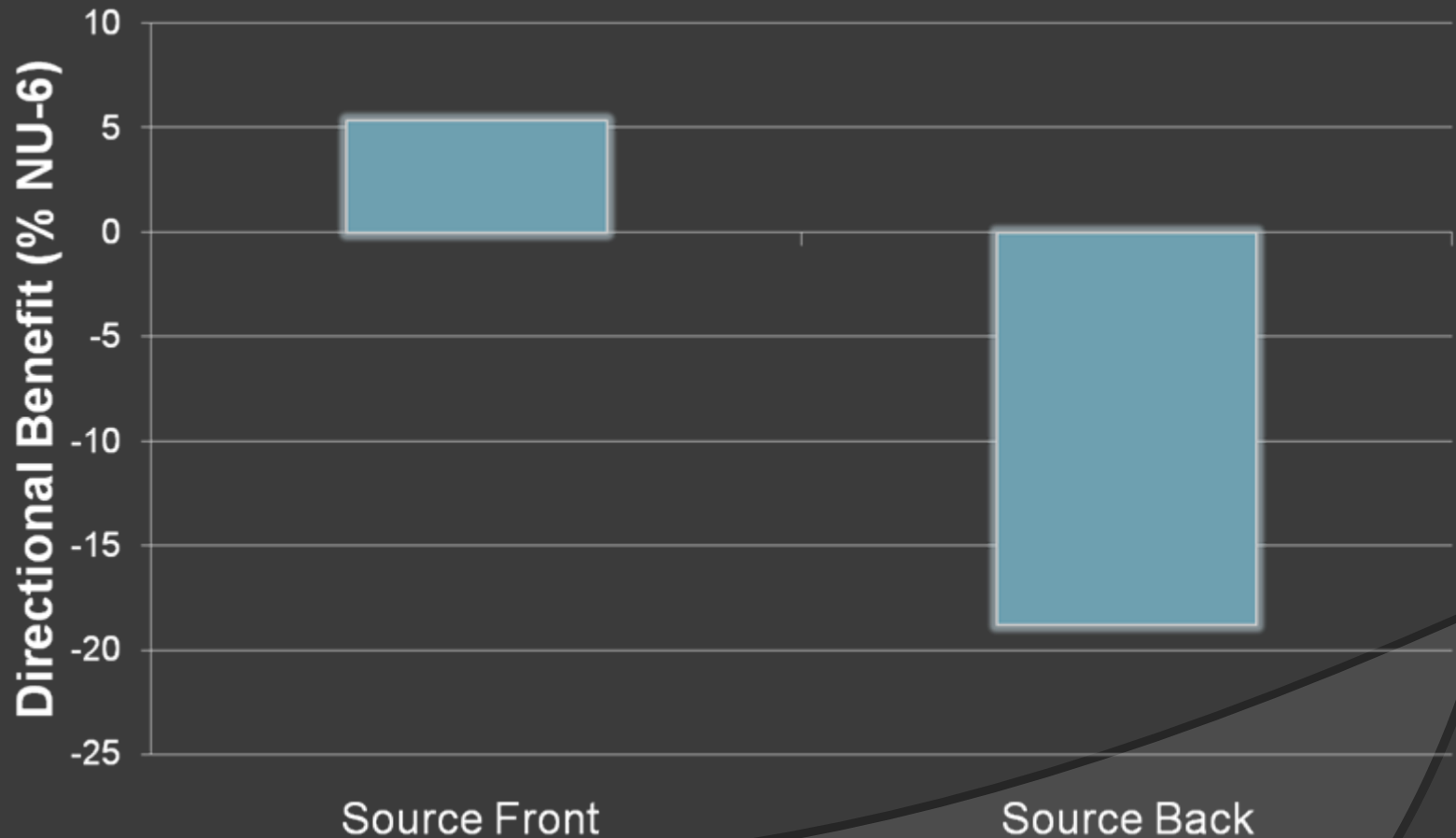


- Congenital sensori-neural loss
- Aided HINT-C score +4 dB
 - Limited audibility, but good understanding speech in noise
- Preferred setting?
 - Full time omni, with directional in program 2 and heavy FM use
 - “I constantly miss talkers I can’t see in the other setting – I don’t even know they are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

A Few General Clinical Considerations When Considering Directional HAs

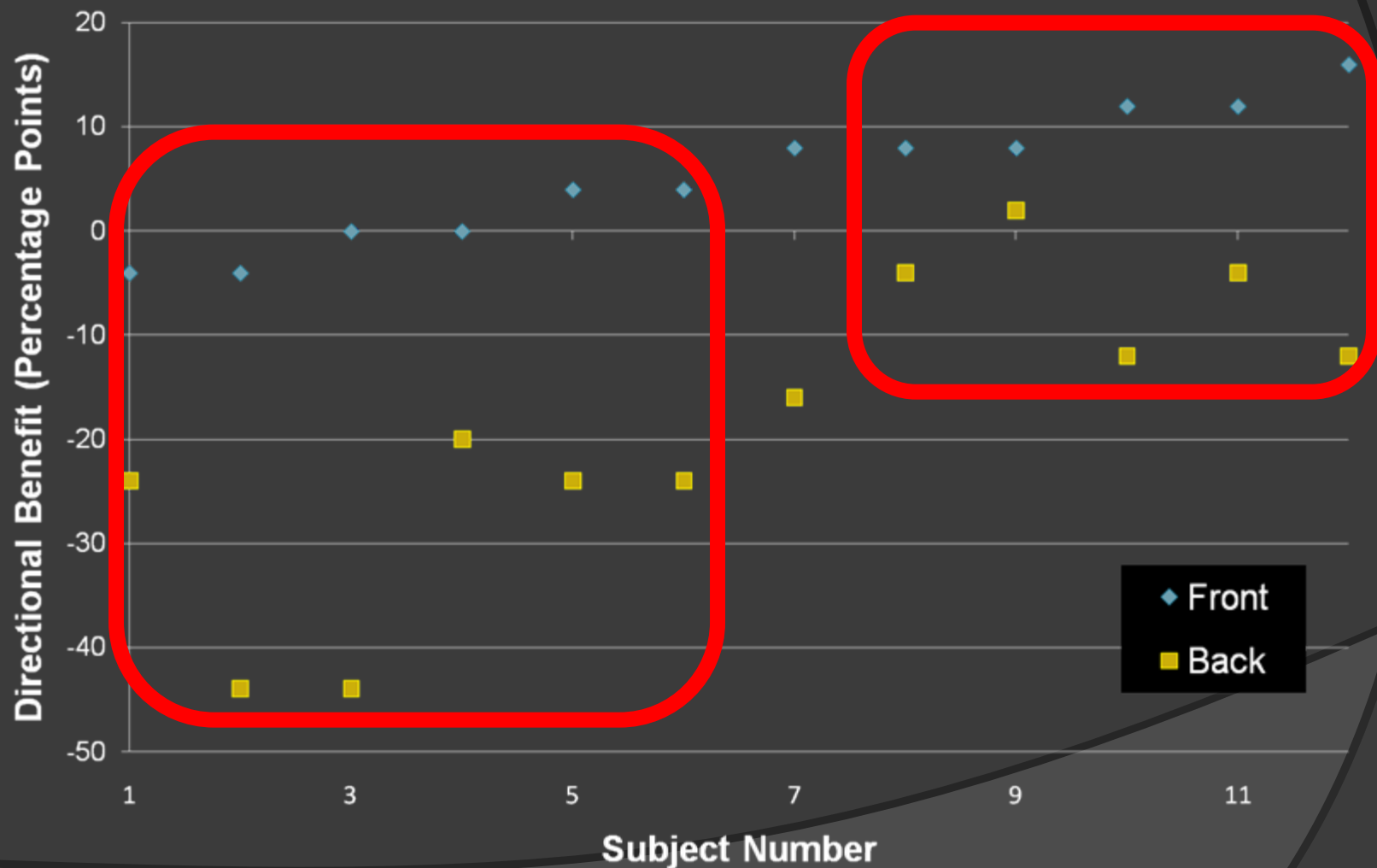
- Can the patient understand some speech in noise without visual cues (people behind them)?
 - If so, they may prefer full-time omnidirectional mode (or FM + environmental).
- Are off-axis voices or environmental sounds important to the individual? If so, is audibility for these sounds limited in directional mode?
 - If so, they may prefer full-time omnidirectional mode (or FM + environmental).
- 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).
- Opinion: The lack of “orientation limitation” is a clear advantage for FM + omnidirectional environmental microphone over directional microphone.

“Overhearing” and Directional Benefit – A Little Data: (N=12) Equal # of Front and Back Presentations

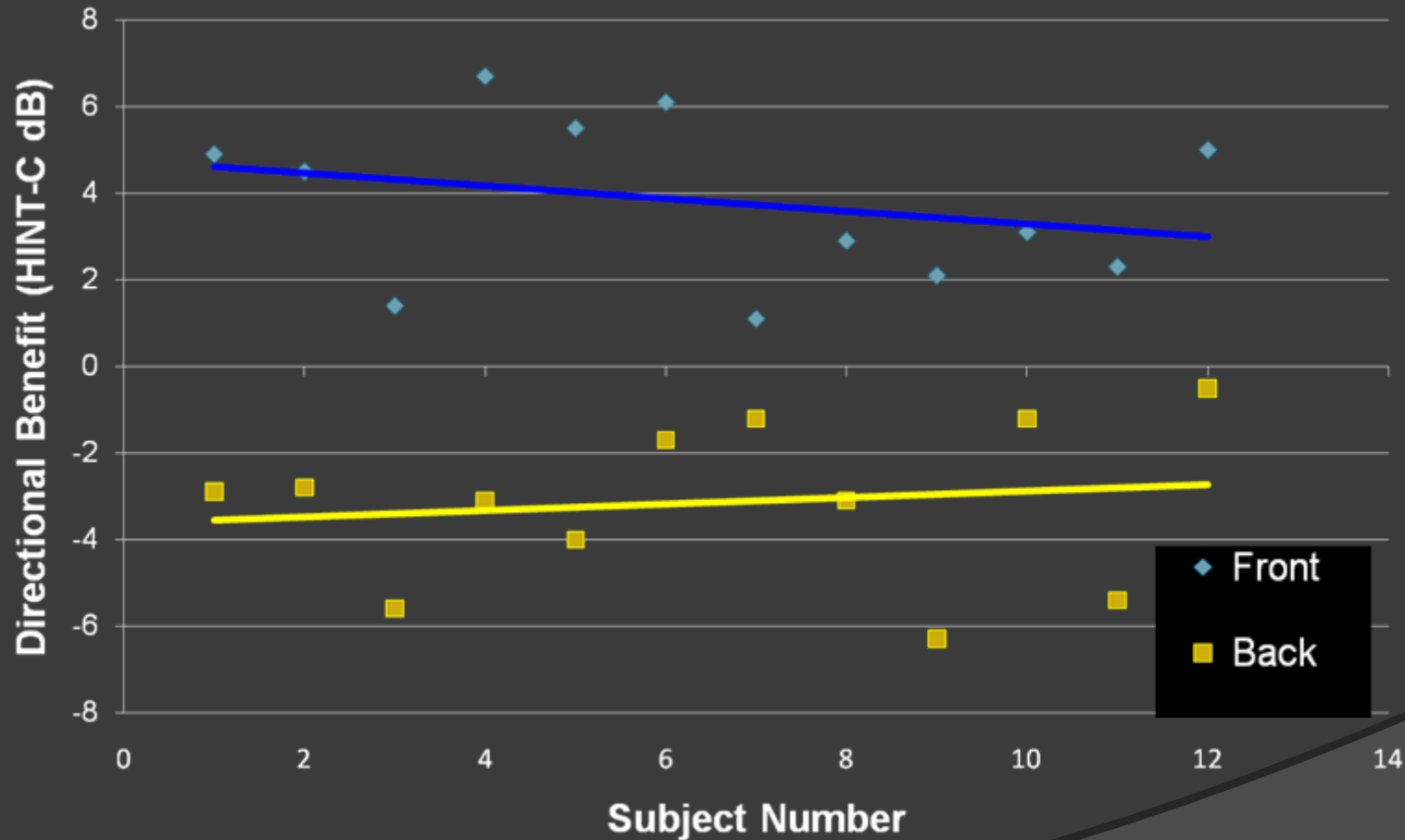


Is Individual Data Useful?

Relationship to Real World Performance?



Not Predictable From “Front Only” or “Back Only” Performance



More Work Needed!

THANK YOU!



Questions?