Auditory Access for Infants and Toddlers Utilizing Personal FM Technology

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Thanks to Dr. Jane Madell
Beth Israel Medical Center, NYC

AMPLIFICATION ASSUMPTIONS

- Early/appropriate amplification
  - is the single most important habilitative tool.\
  - is dependent on the child, and communication environment and NOT hearing loss

AMPLIFICATION ASSUMPTIONS

- When the talker and listener are close and it is quiet
  - ***Standard hearing aids*** work well for patients with mild to severe hearing loss
  - ***Cochlear implants*** work well for patients with severe and profound hearing loss

AMPLIFICATION ASSUMPTIONS

- An ***FM system*** will improve auditory access for every person with impaired auditory function by reducing the negative effects of distance and noise.

GOAL OF ASSISTIVE TECHNOLOGY

- Improve auditory access
- Improve access to language
- Lay foundation for auditory academic learning
- Facilitate socialization
- Facilitate information access/extended learning
- Safety

TECHNOLOGY GOALS

- In summary,
  - Reduce sensory deprivation
  - Maximize use of residual hearing
  - Provide input for auditory learning

FACTORS THAT EFFECT AUDITORY LEARNING AND PERCEPTION

- Hearing loss
- Access to auditory information
- Auditory deprivation
- Language
- Amplification
- Auditory environment

- Which of these can we control?

WHEN IS AMPLIFICATION NEEDED?

- When talker and listener are more than a few feet apart
- Difficult listening situations
- School
- Car
- Dinner table
- When sick or tired
- When hearing is fluctuating
- Any situation in which listening is critical

WHY FM?

FM Improvement (with CI)
24 Children

	Mean improvement	Range
35 dB in quiet	24%	8-44%
50 dB +5 S/N	23%	8%-60%
50 dB 0 S/N	19%	8-24%
35 dB 0 S/N	31%	20-68%

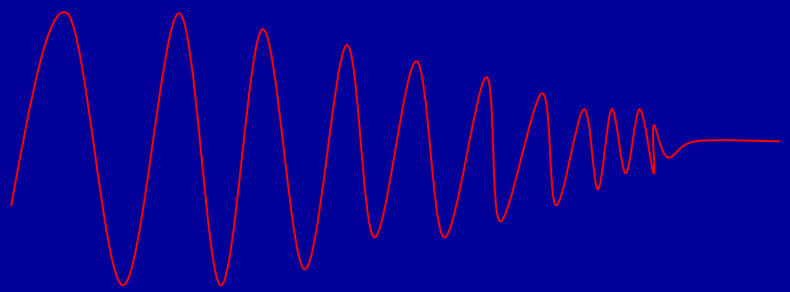
Data from Beth Israel Medical Center, NY, NY; compliments of Dr. Jane Madell, Director

Accessing the Auditory Environment

- Distance between a parent and child
- Background noise ongoing
- Poor acoustics (reverberation)

The Distance Problem

- Distance is a great obstacle to speech understanding
- Audibility and intelligibility decrease as the distance from the speaker increases
- At a certain distance, the background noise can effectively mask the talker's voice



Sources Of Noise at Home

Home Noise	External Noise
People talking	Traffic
Heating systems	Aircraft
Cooling systems	Wind
Appliances	Playgrounds
Movement of furniture	Sirens
Toys	

What Is Signal-To-Noise Ratio?

Also Called Speech-To-Noise Ratio

- ***Signal-to-noise ratio*** (SNR)
  - relationship between the primary auditory signal to background sounds
  - The more favorable the SNR, the more intelligible the spoken message

- Adults with normal hearing
  - require a SNR of approximately *+6 dB* in order to hear the spoken message as consistently intelligible.
  - desired signal needs to be about *twice as loud* as background sounds.

Children

- Children
  - need a much more favorable signal-to-noise ratio in order to receive intelligible speech
  - SNR needs to be approximately +15 dB to +20dB
  - desired signal needs to be about 10 times louder than background sounds!

Children who need improved SNR

- Typical children
- Children with
  - any type and degree of hearing problem
  - ear infections
  - unilateral hearing loss
  - auditory processing problems.
  - learning disabilities
  - attention problems
  - visual disabilities
  - behavior problems
  - developmental disabilities
  - first language is not the language of the speaker

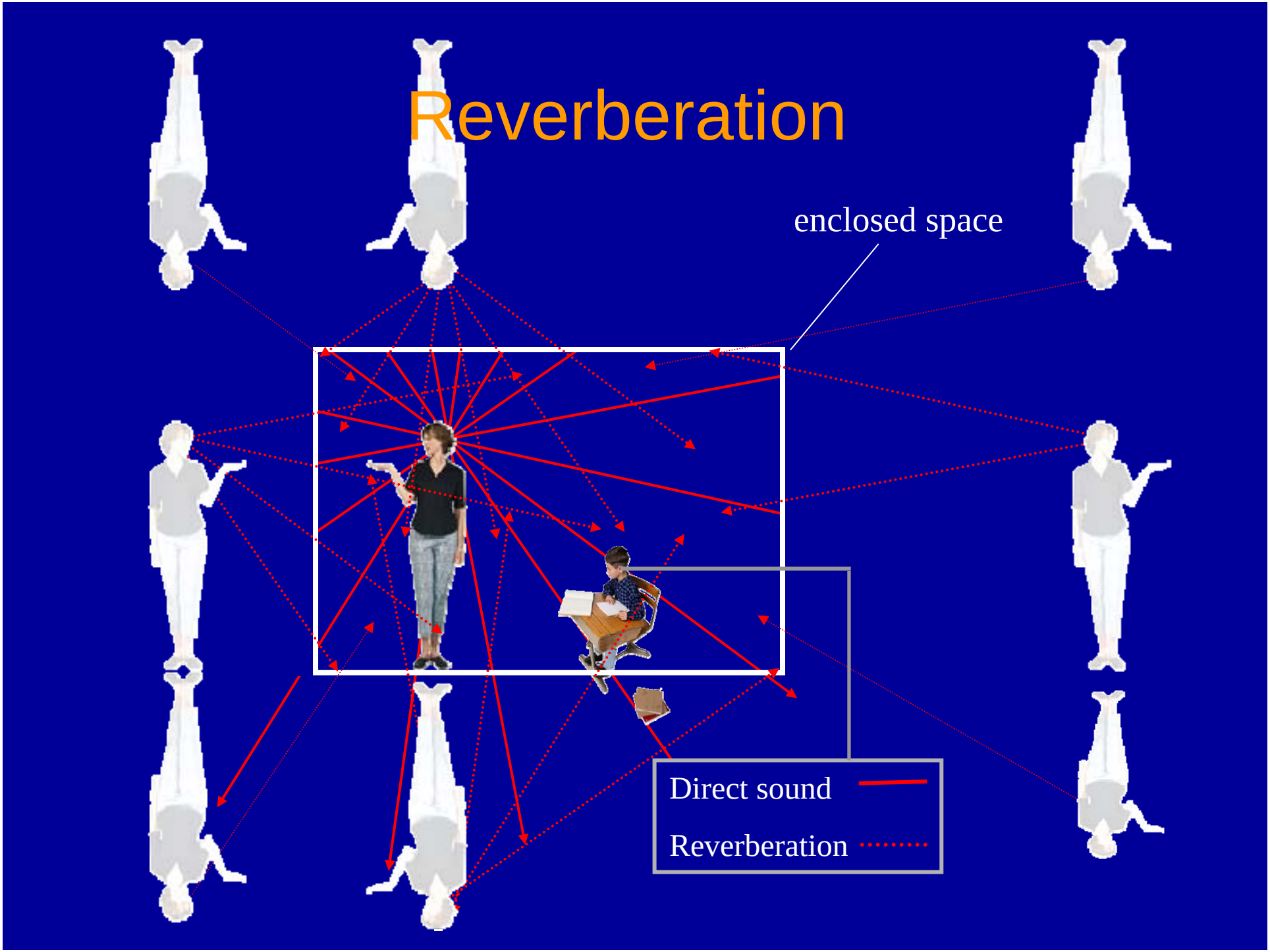
Unfortunately, typical classrooms have an *inconsistent* and poor signal-to-noise ratio of about +4 dB.

- A classroom's signal-to-noise ratio can vary minute by minute from about +5 dB to worse than -20dB, depending on teacher and pupil positions and background noise.

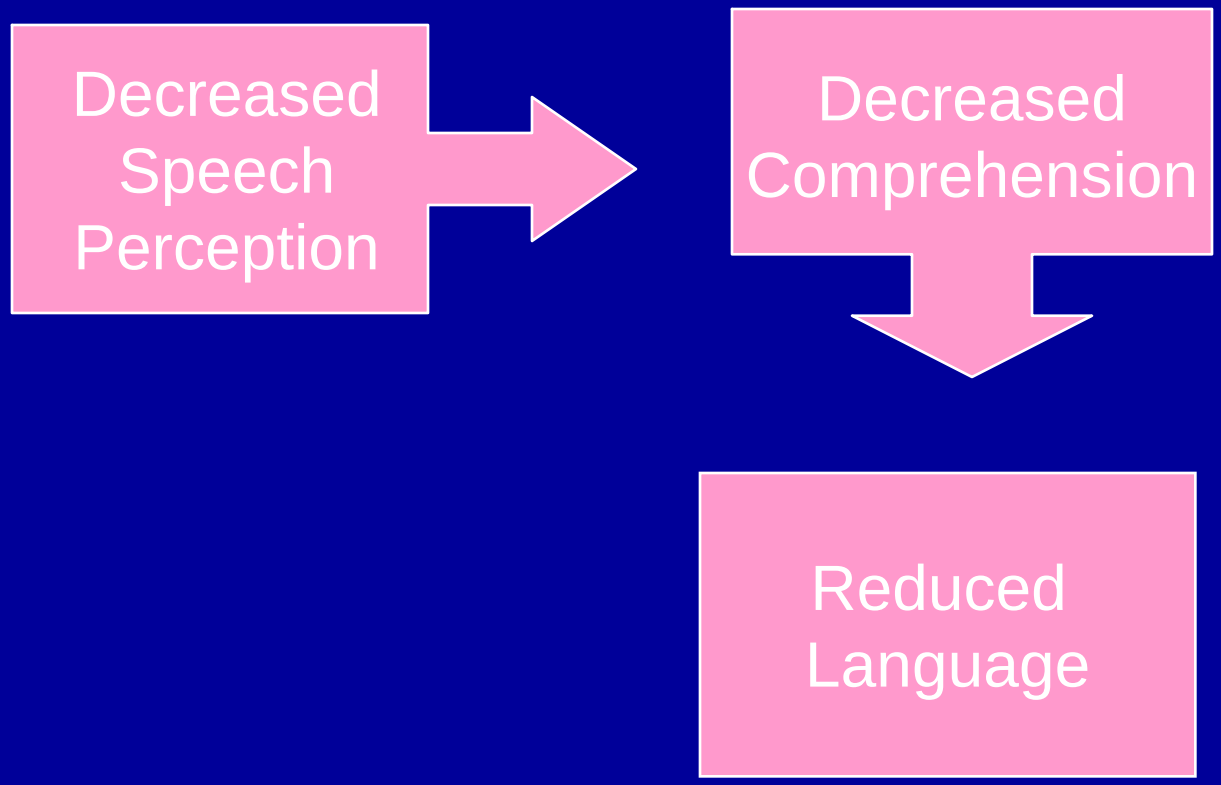
Reverberation

- Reverberation is the reflection of sound waves off of hard surfaces
  - high ceilings
  - untreated windows
  - chalk boards
  - concrete
  - tile floors

Reverberation



Implications



Two Ways to Manage, Improve, and Control the Signal-To-Noise Ratio (SNR)

- Positioning:
  - Remain, physically, as close as possible to the desired sound source -- ideally within 6 inches
  - This can work well for an infant who is being carried
  - Unfortunately, physical positioning does not work in many situations where talker and child cannot remain in fixed positions

- **<u>If you cannot remain consistently very close to the child, use a remote wireless microphone</u>**:
  - A remote microphone, placed or worn within 6 inches of the desired sound source, allows the listener to remain, t*echnologically* close to the talker while providing a physical extension of distance hearing.

CLOSE MICROPHONE

- Reduces negative effect of
  - distance
  - noise
  - poor acoustic environment
- Improved ability to attend to an auditory task

DO PEDIATRIC AND ADULT EVALUATIONS DIFFER?

- Do you need a complete audiogram?
- Are electroacoustic and real ear data sufficient?
- Do children need to hear different things than adults?
- Monaural vs binaural?
- FM?

FM's for Infants

- Noisy homes
- Reduced negative effect of distance
- Reduced negative effect of noise
- Improved speech signal
- Increased parental output

The Evaluation Process

- Selection
- Verification
- Validation

Selection

- Not all systems are equal
- What works for one child may not be best for another child
- No one FM solution meets all needs

Internal FM Receiver Configurations

- Ear level
  - –HA with integrated FM
  - –CI with integrated FM
    - (Not yet)
  - –FM only

Internal FM Receiver Configurations

- Body
  - –Button transducers
  - –BTE transducers

- Soundfield
  - Room

  - Personal

External FM Receiver Configurations

- Integrated audio shoe
  +FM receiver

- Two pieces
  – (audio shoe + FM receiver)

- Cube adaptor (for CI only)


FM+M
FM
PHONAK

- Body worn FM
  - Direct audio input (DAI)
  - Neckloop
  - Silhouette

Factors in Making a Selection

- Internal Receivers
  - Pros
    - Fewer parts
    - Ease of use
    - Ease of maintenance
    - Compatibility is assured
  - Cons
    - If something breaks the whole system is down
    - Inability to wear primary device alone

Factors in Making a Selection

- External Receivers
  - Pros
    - Can use primary device alone
    - Can use FM alone if HA is being repaired
    - Can put FM onto different HA if HA is being sent for repair or a new HA is purchased
  - Cons
    - Easier to loose parts
    - More possible parts for repair
    - Compatibility and connectivity
    - May require additional battery
    - If device is agency owned – where can it be used?

Receiver Selection Decisions

- Direct input system
  - Always with the child
  - Always in the appropriate place
  - Monitoring issues with CI

Receiver Selection Decisions

- Room soundfield system
  - Provides assistance to everyone in the room
  - Works best when close to the loudspeaker
  - Easily monitored
  - Not best for HI kids

Receiver Selection Decisions

- Personal desk top system
  - No compatibility problems with HA or CI
  - Can be easily monitored
  - Must be carried around room as child moves
  - Not appropriate for infants

Transmitters

- Boom
- Lavaliere
- Clip on
- Hand held
- Table top

Factors in Making a Selection

- Transmitters
  - Boom
    - Pros
      - Always in the correct position
      - Noise cancelling
    - Cons
      - May interfere with lipreading
      - Not popular with teachers

Transmitters cont.

- Lavaliere
  - Pro's
    - 2nd best choice for placement
    - Ease of use by teacher or speaker
    - Microphone options – degrees of directionality
    - Reminder to parents to TALK, TALK, TALK
  - Con's
    - Some people do not like wearing things around their necks
    - External noise from clothing, jewelry etc

Transmitters cont.

- Clip on
  - Pro's
    - People like it
    - Microphone options for degrees of directionality
  - Con's
    - Almost always in the wrong place
    - External noise from clothing, jewelry etc
    - Microphone cord serves as the antenna so it has to be fully extended to work optimally
    - Greater potential for the microphone cord to break

Transmitters cont.

- Hand Held
  - Pro's
    - Can be easily handed to different speakers
  - Con's
    - Talker needs to remember to hold near mouth
    - Requires one hand – intrudes on talker's freedom of movement
    - Potential for external noise
    - Not possible with young children

Transmitters cont.

- Table top
  - Pro's
    - Picks up signal from multiple speakers who are close
  - Con's
    - Signal is not as good as that from a close mic
    - Not appropriate for infants and toddlers

Recommendations

- Infants (less than 8 months)
  - Less than severe HL – may not need FM
  - Severe to profound HL
    - Body worn integrated FM/HA (button transducers)
      - Reduces feedback
      - More durable
    - BTE HA with FM only if you do not need to reduce high frequencies because of feedback

Our Recommendations

- Toddlers
  - BTE HA with FM
    - Select HA first to provide optimal benefit
    - If integrated FM is available – great
    - If FM and audio shoe are integrated – very good
  - Body worn system if needed to reduce feedback
  - CI + FM

Transmitters

- Boom mic
- Lavaliere
- Clip on – with lots of direction

The FM Evaluation

- Electroacoustic measures
- Real Ear measures
- Behavioral measures

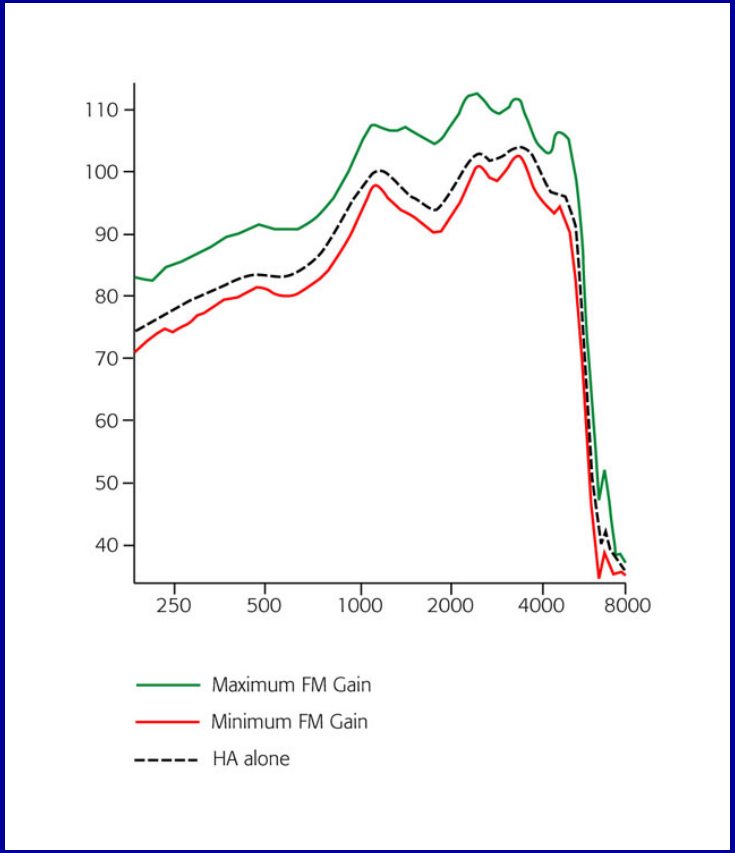
FM VERIFICATION
Electroacoustic Measures

- FM performance with HA's should be verified through the use of real ear or 2cc coupler measurements
- The signal used to verify the FM performance should be the same one used to verify the hearing aid performance
- Contact FM and/or HA Test Box Manufacturers for specific procedures

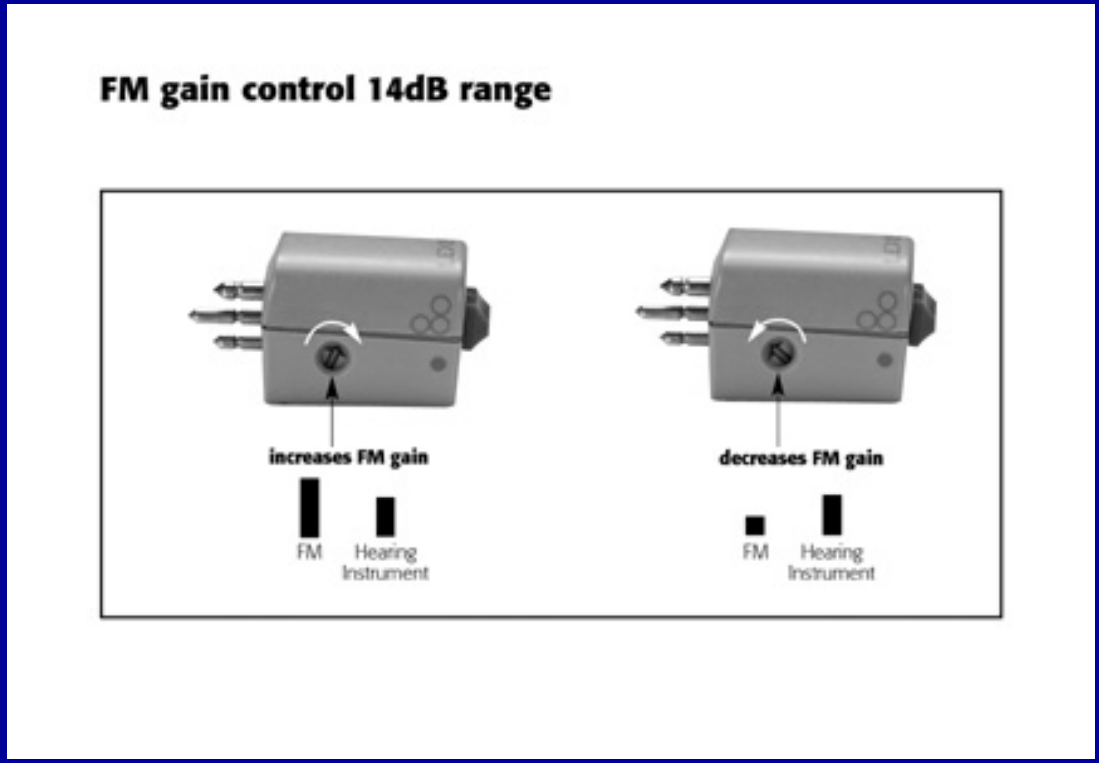
POINTS TO REMEMBER

- Because of compression in both the hearing instrument and the transmitter, “transparency” of the FM may not be possible
- When adjusting the gain and output of the FM signal you MUST consider the greater input level into the FM microphone due to placement.
  - 80 dB SPL rather than 65 dB SPL for a boom or chest level mic
- The manner in which the FM transmitter will be used must be considered when adjusting the FM gain.

ADJUSTING FM GAIN



ADJUSTING FM GAIN



FITTING AN FM (cont.)

- ASHA recommends 3 fitting strategies or protocols for FM fittings (Guidelines for Fitting and Monitoring FM Systems, ASHA 2003)
  - Equal Output
  - Equal Gain
  - 10 dB FM advantage

DEMONSTRATING BENEFIT

- Electroacoustic measurements
- Real ear measurements

- *Are we done yet?*

DEMONSTRATING FUNCTIONAL BENEFIT

- Factors
    1. Test room set-up
    2. Microphone placement
    3. Test materials
    4. Hearing aid/CI alone (R, L, B)
    5. FM and HA/CI

Behavioral Measures

- *Is it loud enough?*
  - Soundfield noise band thresholds
    - unaided
    - With technology - Right, Left, Binaural, + FM
  - Speech thresholds
    - Music
    - Ba, Sh, S
    - Spondee words or objects
    - Familiar objects
    - Body parts

Speech Perception
Is it clear?

- Infants - VRISD
- Toddlers
  - Monosyllabic words
  - Sentences
    - Potato Head task
    - Picture
    - Repeat back

Test Conditions

- Monosyllabic words
  - 50 dB HL Quiet
  - 35 db HL Quiet
  - 50 dB HL +5 SNR
- Sentences
  - 50 dB HL Quiet
  - 35 db HL Quiet
  - 50 dB HL +5 SNR
  - 50 dB HL +10 SNR

Selecting Speech Test Materials

- Goal of the evaluation
  - Obtain the best possible test results
  - Compare to typical peers
  - Compare to other HI peers
  - Monitor progress
  - Monitor auditory learning
  - Monitor function in different listening conditions

FM - CI Evaluation

	CI (R) (L)	CI or HA (R) (L)	CI+HA CI + CI	CI+HA+FM CI+CI+FM		Test Stimulus
Warble tone						
500 Hz						
1000 Hz						
1500 Hz						
2000 Hz						
3000 Hz						
4000 Hz						
Speech Perception/Quiet						
50 dBHL						
35 dBHL						
Speech Perception/Noise						
50 dB + 5 S/N						

Functional Listening Evaluation
(Adapted from Johnson and Von Alman)

	Close/Quiet	Close/Noise	Distant/Quiet	Distant/Noise
CI Alone				
CI + FM				

Analyze the results

- Speech perception with FM + HA or CI should be better than HA or CI alone for soft speech
- Speech perception with FM + HA or CI should be better than HA or CI alone for speech in noise
- Speech perception in noise via the “FM alone” (receiver set to FM only) should be significantly greater than that obtained in noise with hearing aid or CI alone

INDIRECT MEASURES

- Sifter
- Pre School Sifter
- Hearing Performance Inventory for Children
- LIFE
- MAIS, ITMAIS
- Monitoring language levels

Summary

- The FM fitting protocol used should be determined by how the FM transmitter will be used
- FM gain for hearing aids should be verified via real ear or 2cc coupler measurements
- FM Benefit should be demonstrated through behavioral testing including thresholds measures and speech perception testing in noise and quiet


99. 3. 7

Mark

- Normal hearing (PTA R 7 dB, L 6 dB)
- Word recognition
  - 50 dB (quiet) 100%
  - 35 dB (quiet) 84%
  - 50 dB +5 S/N 84%
  - 50 dB 0 S/N 64%
  - 35 dB 0 S/N 44%

Josh

- Mild conductive hearing loss
  - AC right 20 dB left 15 dB
  - BC right 4 dB left 6 dB
- Word recognition
  - 50 dB (quiet) 100%
  - 35 dB (quiet) 84%
  - 50 dB +5 S/N 88%
  - 50 dB 0 S/N 64%
  - 35 dB 0 S/N 56%

Lizzy 12 yrs

PTA Right 65 dB Left 74 dB

	Binaural	FM
50 dB	88%	100%
35 dB	52%	92%
50 dB+5 SNR	70 %	92%

AVI 4 yrs

PTA Right 84 dB Left 92 dB

	Binaural	FM
PBK 50 dB	100%	100%
35 dB	72%	92%

David 4 yrs

PTA Right 104 dB Left 102 dB

		Binaural	FM
NU CHIPS	Standard	64%	90%
NU CHIPS	open set	56%	76%
AB lists	vowels		90%
	consonants		70%
	Whole words		50%

A.S. 9 yrs

NU 6	Right	Left	Bin	FM
50 dB live voice	72%	54%	80%	72%
50 dB recorded			66%	
35 dB live voice			68%	60%
50 dB +5 S/N			64%	54%

When should an FM be primary amplification?

- When hearing aids do not provide sufficient auditory access.
- When in a noisy environment.
- Pre - CI

OTHER FM ISSUES

- Wide band vs narrowband
- Multiple microphones
- Appropriate use of FM system
- Counseling (parents, teachers, family)
- Troubleshooting
- Preventive Maintenance

Thank you!