A Tale of Two Fittings: Two case studies on qualifying benefit and defining success of FM Systems

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Audiology

Foreword

This is a comparison between two case studies who look similar on paper but their outcomes when using an FM system are drastically different. These patients were seen by the same audiologist, who, after reflection and research, decided to revisit the cases to identify other factors that may have impacted the outcomes.

Welcome!

Quick Bio

- Neil Wright, AuD
- Research Audiologist at GN ReSound in Glenview, IL
- Received AuD from Northwestern University
- Financial disclosure: I am an employee of GN ReSound.

Outline

- (0-5): Introductions
- (5- 20): FM basics & research – benefits in noise & distance
- (20-30): Case Study 1: A tale of success
- (30-40): Case Study 2: When hearing aids alone suit the patient
- (40-45): Comparing patient characteristics
- (45-55): identifying success and highlight success with patients
- (55-60): Conclusions and Q&As

Learning Goals

- To quantify the benefits of FM systems
- To identify various factors that may influence patient performance with FM systems
- To demonstrate fitting and counseling strategies when fitting patients with FM systems

FM Systems

Let's get started

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FM Systems – The Basics

- Microphone, transmitter, receiver
- 1st systems designed to transmit signal wirelessly via FM
  - Analog transmission
  - Allow for multiple receivers to tune in to the same microphone and transmitter
- More recent systems use digital wireless transmission
  - 2.4 GHz
  - Both 2.4 GHz and FM transmission
- Why does this matter?
  - Digital transmitters may not work with a conventional receiver – so it is critical each piece works together to ensure functionality

FM Systems – The Basics

- Speaker wears the remote microphone
  - Typically worn a few inches from the speakers mouth
- Speech transmitted wirelessly to the FM receiver
- Receivers plugged into hearing aids – presents speech to hearing aids
  - Plugged in via a DAI boot, integrated FM battery door, or accessory device for non-FM compatible HAs (ex: custom devices paired to FM accessory)
- Receivers plugged into hearing aids – presents speech to hearing aids
- Speech presented without degradation

FM System Verification:

FM Transparency & SNR Advantage

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Verifying FM: FM Transparency

- Definition: condition in which inputs of 65 dB SPL to both the FM and HA microphones of a HA + FM system result in equal outputs from the hearing instruments
  - Transparency is defined as FM offset = 0 dB
- All verification measures should be measured using 2cc coupler
  - Except behavioral verification
- AAA (2008, 2011) recommends verifying FM transparency by calculating average FM offset at 750 + 1000 + 2000 Hz
- Recommended to reprogram for non-transparency when FM offset is ≥ 2 dB or ≤ -2 dB
  - FM transparency measures should be completed with automatic noise reduction OFF if possible
  - Keep HA microphone active

FM Transparency: Electroacoustic Verification

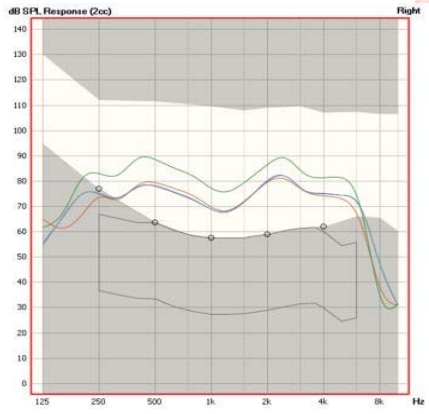
1. Use calibrated speech signals or speech-like signals using a test box
2. Verify HA alone first using either Real ear measures or 2cc coupler & RECD measures
   - All further measurements compare FM & HA using 2cc coupler
3. Evaluate $EHA65_{SPL}$ without FM Receiver attached
4. Attach FM Receiver in default setting & set transmitter to MUTE
   - EHA/FM65SPL
5. Compare 1st two measurements to test impedance or distortion with FM receiver attached
6. Evaluate $EFM/HA65_{SPL}$: Place HA outside test box (HA mic is active, keep test room quiet!) & FM mic in test box
7. Subtract HA from FM (EHA/FM65SPL – EFM/HA65SPL = FM transparency)
   - Subtract at 750, 1000, & 2000 Hz
8. If differences observed, make programming changes and retest
   - Perform final listening check

FM Verification: SNR Advantage

- Once transparency is verified, SNR advantage can be measured
- Defined as increase in signal-to-noise ratio when FM signal is added to or substituted for hearing aids own microphone
- FM should provide +10 dB output under typical use conditions
  - Typical speech at FM = 65 dB_{HL} or 80 dB_{SPL}

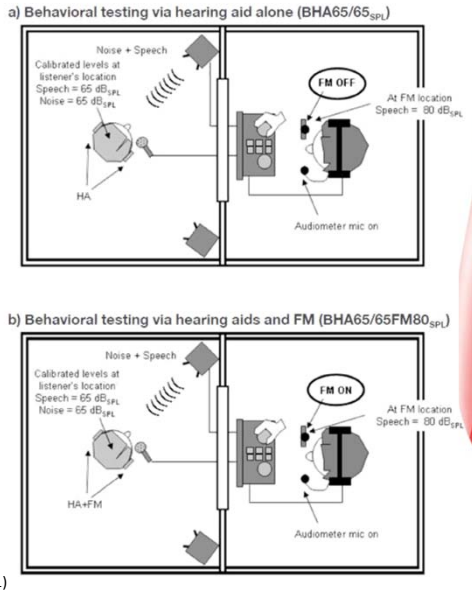
<u>Calculating SNR Advantage</u>

- Measure 65 dB_{SPL} input to hearing aid microphone at 1-2 meter
- Measure 80 dB_{SPL} input to FM microphone at 15-20 cm distance
- Subtract 1st measure from 2nd
  - Result = +10 dB to confirm SNR advantage



FM Verification: Behavioral Verification

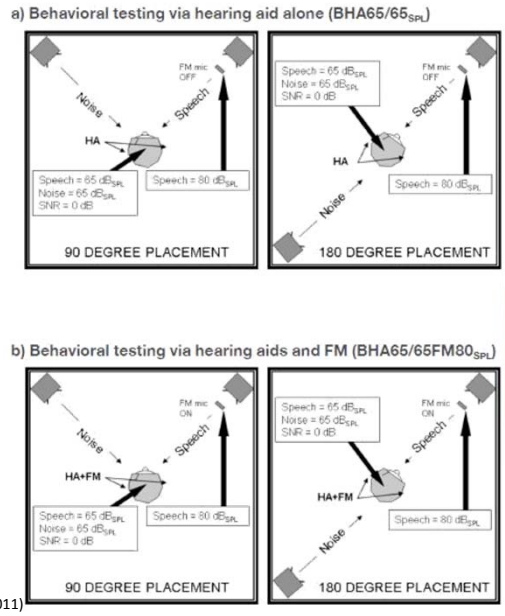
- Speech recognition testing to ensure FM benefit – FM should significantly improve performance over HAs alone
- 2 behavioral testing set ups: 1 speaker vs 2 speakers
- 1 Speaker test utilizes front speaker with both speech and noise coming from the front
  - FM mic is placed outside test booth 6" from testers' mouth using MLV for speech input
- 1st measure: FM mic off, speech input: 80 dB_{SPL} at FM mic, speech & noise: 65 dB_{SPL} at HA user
  - $BHA65/65_{SPL}$ - Fig. a)
- 2nd measure: same set up but FM mic is turned ON
  - $BHA65/65FM80_{SPL}$ – Fig. b)



American Academy of Audiology Clinical Practice Guidelines: Remote Microphone Hearing Assistance Technologies for Children and Youth from Birth to 21 Years. (2011)

FM Verification: Behavioral Verification

- 2 speaker tests: 90º or 180º degree placement
  - 2 speaker configuration allows for FM mic to be inside test booth, input standardized compared to 1 speaker only
- FM mic placed inside test booth, 3-6" in front of speaker presenting speech
  - Speech and noise level at listener should be 65 dB_{SPL}
  - Speech level at FM mic should be 80 dB_{SPL}
- 2 measures:
  - 1st HA alone, FM mic muted
  - 2nd HA + FM, FM mic active



American Academy of Audiology Clinical Practice Guidelines: Remote Microphone Hearing Assistance Technologies for Children and Youth from Birth to 21 Years. (2011)

FM System Benefits

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FM Systems: Benefits

- 3 Key Benefits
  - Increased speech understanding in noise
  - Improved SNR
  - Improved understanding at a distance
- Positive impacts in difficult listening environments

FM Systems – Benefits in noise

- Benefits for Adults
  - Boothroyd, A. (2004) highlights the substantial impact of adding an FM system for adults with mild to severe hearing loss
  - Addition of FM system in noise resulted in performance similar to hearing aids in quiet for most participants
  - Show improvement in speech recognition even when noise was louder than speech at HA microphone
  - Similar results seen in other studies
  - **BUT**, these subjects reported they were unlikely to purchase the FM systems – More to come…

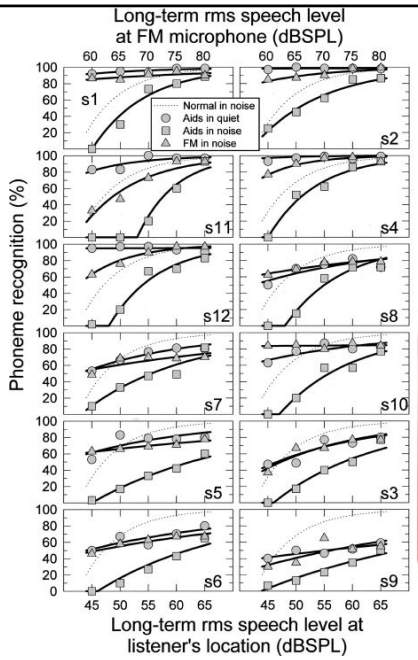

Figure 3. Performance versus intensity functions of 12 subjects under three listening conditions. Noise level at both the listener's location and the FM microphone was 55 dB SPL

Figure taken from Boothroyd, A. (2004) Hearing Aid Accessories for Adults: The Remote FM Microphone. Ear & Hearing. 25;22-33.

FM Systems – Benefits in noise

- Benefits for Children
  - Anderson and Goldstein (2004)
  - Mild to severe hearing loss in 8 subjects (9-12 years old)
  - FM system + hearing aids improved speech perception in typical classroom
    - Improved performance over hearing aids only and infared soundfield system
  - Preferable to ceiling mounted infrared system in both performance and esthetics
  - Socially easier to accept in the classroom than other systems
    - Easiest listening, preferred system to use in class

Table 3. Mean accuracy of participant responses for each listening condition.

Participant	Hearing aids only	Infrared SF	Desktop FM	Personal FM	Replication	
1	68.0%	74.6%	84.0%	86.7%	92.0%	P
2	76.0%	71.3%	86.7%	95.3%	95.3%	P
3	80.6%	82.0%	92.0%	95.3%	92.0%	P
4	89.3%	84.0%	92.7%	96.7%	98.0%	P
5	93.3%	95.3%	98.7%	100.0%	88.0%	HA
6	88.7%	82.0%	97.3%	89.3%	99.3%	D
7	90.7%	93.3%	99.3%	97.3%	98.7%	D
8	72.7%	82.0%	97.3%	94.7%	96.7%	D
Mean (SD)	82.4 (9.4)	83.1 (8.2)	93.5 (5.7)	94.4 (4.3)		

Note. P = personal FM, HA = hearing aid alone, D = desktop sound field system.

Anderson, K., Goldstein, H. (2004) Speech Perception Benefits of FM and Infrared Devices to Children With Hearing Aids in a Typical Classroom. *Language, Speech, and Hearing Services in Schools.* 53:169-184.

Case Study 1:

"Amy"

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Case Study 1: "Amy"

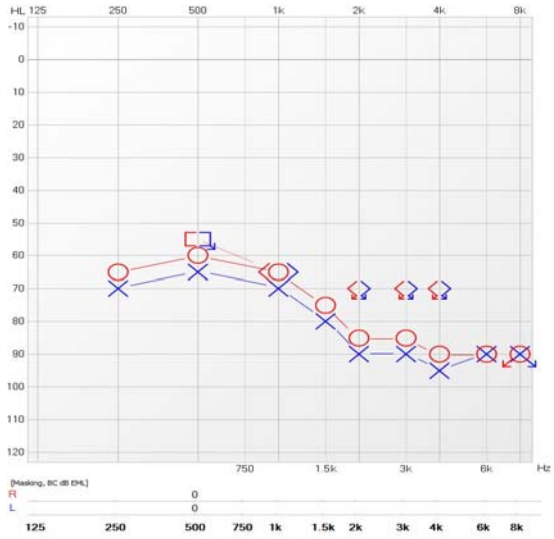
Basic Characteristics

- Female
- 84
- Long-time bilateral hearing aid user
- Comes to the office with her daughter
- Knowledge seeker
  - Wants to maximize benefits from hearing aids through information gathering
- Limited mobility, uses cane

Case Study 1: "Amy"

Audiological results

- Severe-to-profound sensorineural hearing loss
- SRT
  - L: 65 dB HL
  - R: 65 dB HL
- WRS
  - L: 44% at 95 dB HL
  - R: 48% at 95 dB HL



Case Study 1: Amy

Additional Characteristics

- Outgoing, social
- Looking to get improvements on the phone and in noise
- Daughter concerned she is not always hearing her doctors during appointments
- Still enjoys going to family events/out for dinner
- Continued trouble in noise – family events getting harder

- Qualifies for Cochlear Implantation based on AZBio testing
- Patient too concerned with surgical complications, does not intend to pursue implantation
- Ready to purchase new hearing aids; needs added help in noise
- Amy and her daughter describe themselves as goal-oriented people

Case 1: Amy's Outcomes

Short-term Outcomes: 0-4 weeks

- Fit with bilateral RIE hearing aids (with custom receivers) and Digital FM system with Bluetooth compatibility
  - FM Receiver in integrated battery door
  - Paired phone via Bluetooth for wireless streaming
  - Real ear completed, however transparency not confirmed
  - No specific goals set with audiologist
- Saw benefits in noisy environments
- Had some trouble with using Bluetooth
  - Needed to re-pair it several times
- Daughter notes she is more engaged in one-on-one conversations

Case 1: Amy's Outcomes

Long-term outcomes: 1-6 months

- Decided to keep FM system due to perceived benefit
- Phone connection issues resolved, still some struggles on the phone
- Major positive impact for conversations in noise
- Group conversations reported as much improved
- Amy states she sometimes has grandkids wear FM mic
- **Overall describes the FM system as successful**

Case Study 2:

"Michelle"

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Case Study 2: Michelle

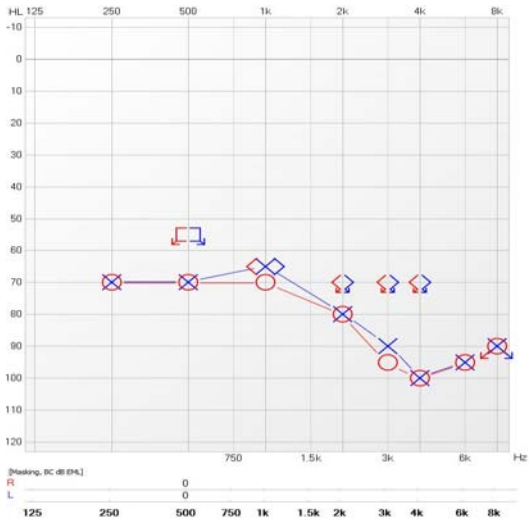
Basic Characteristics

- Female
- 85
- Long-time bilateral hearing aid user
- Comes to office with daughter
- Service seeker
  - Wants the audiologist and hearing aids, assistive devices to maximize benefits from hearing aids
  - Sees her role in maximizing benefits as minimal
- Limited mobility
  - Confined to wheelchair

Case Study 2: Michelle

Audiological Results

- Severe-to-Profound sensorineural hearing loss
- SRT
  - L: 70 dB HL
  - R: 75 dB HL
- WRS
  - L: 44% at 95 dB HL
  - R: 40% at 100 dB HL



Case Study 2: Michelle

Additional characteristics

- Friendly, but less outgoing than Case 1
  - More shy regarding hearing loss
- Still enjoys a rich family life
  - Often goes to family events
- Gradual vision loss has become a larger burden in recent years
- Not in noisy environments as often as Case 1 but relies on hearing aids in those environments
  - Given vision loss and limited mobility, Michelle looking for better outcomes with hearing aids
- Qualifies for cochlear implantation based on AZBio results
- Due to ailing health and recovery time, does not wish to pursue cochlear implant
- Other expenses and sensory loss means needs the technology to be a significant advancement to justify high costs
- Daughter willing to help cover cost if technology is effective

Case 2: Michelle's Outcomes

Short-term Outcomes: 0-4 weeks

- Michelle fit with bilateral BTE hearing aids with standard skeleton earmolds and a digital FM system without Bluetooth compatibility
  - Chose simpler system due to vision difficulty
  - FM receiver integrated into battery doors
  - Real ear completed, however transparency not confirmed
  - FM system goals not set with audiologist
- Daughter noticed some benefit at family events – Michelle more engaged in conversations
- Michelle did not feel it helped very much

Case 2: Michelle's Outcomes

Long Term Outcomes: 1-6 Months

- FM system trial period extended for 3 month trial
- Patient noted improvement from new hearing aids compared to old hearing aids
- Continued to struggle with the FM system
- Ultimately returned the FM system
  - Cited high cost of system, difficulty using system, and limited benefit relative to new hearing aids
  - However, she kept the hearing aids
- **Overall describes the FM system trial as a Failure**

Case Comparisons

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Case Comparison: Amy and Michelle

Similarities

- Similar hearing losses, speech thresholds
- Similar speech understanding level
- Both have a supportive family system
- Both struggled with speech understanding in general, and completely fell apart in noise
- Both had other complicating health concerns
- Transparency not completed
- Both were long-term hearing aid users
- Both were fit with similar levels of hearing aid technology
- Physical fit good for each, satisfaction with new hearing aids high
- Objective real ear were completed for both patients
- Both of the families (daughters specifically) noted at least some benefit

Then what's the difference?

Case Comparison: Key Differences

Case 1: Amy

- Main other health concern was limited mobility
- Cost less of a factor
- Highly motivated to learn and utilize new technology
- **Had developed her own clear, defined, tangible set of goals**

Case 2: Michelle

- Other comorbid sensory losses
  - severe vision loss had major impact on interaction with environment
- Cost was a significant factor
- Less motivated to learn, wanted technology to do the work
- **No clear set of goals**

Establishing clear patient goals could be the key!

FM Systems: Goals and outcomes meeting expectations

- In Boothroyd (2004), subjects ultimately did not believe that they were benefiting from the FM system, even with the objective evidence
- Chisolm *et al* (2004) focused on the effect of goal setting on perceived benefit with FM systems
- Participants set goals for specific environments using the hearing aid alone then adding an FM system
  - COSI – Client Oriented Scale of Improvement questionnaire
  - Max 3 goals; each given priority ranking
  - Conversation with group in noise most common category of goals set across subjects
  - Subjects given written, oral, & pictorial instructions on how to achieve set goals
- Perceived improvement in FM shown in all environments where goals were established
  - Significant perceived improvement from hearing aids alone

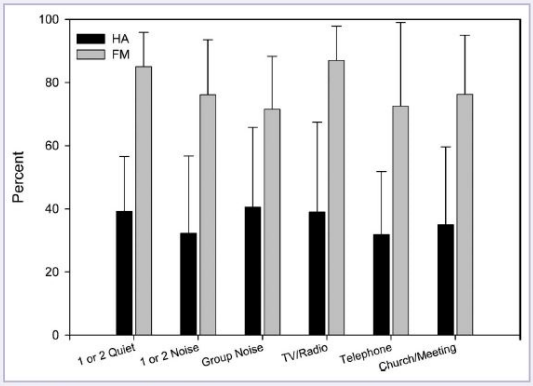

Figure 1. *With regard to Final Ability, means and standard deviations of the percent hearing ability when listening with hearing aids alone and with hearing aids coupled to FM systems are shown for listening situations assigned to COSI categories.*

Figure taken from: Chisolm, T., McArdle, R., Abrams, H., Noe, C. (2004) Goals and Outcomes. *The Hearing Journal.* 57(11): 28-35.

FM Systems: Goals and Outcomes

- Chisholm (2007) followed up with a larger number of subjects at 6 weeks then 1 year post
  - Again, subjects set environment related goals and instructions on how to best meet them
- CPHI is a 145 item questionnaire with 5 subscales
  - Self-perception of communication performance
  - Scored 1-5, 5 being best performance
- Subjects perceived significant improvements over hearing aids alone with an FM system at both 6 weeks and 1 year post-fitting
- All 36 participants were given option to keep their FM systems based on performance after 6 weeks
  - **All 36 chose to keep the FM system**

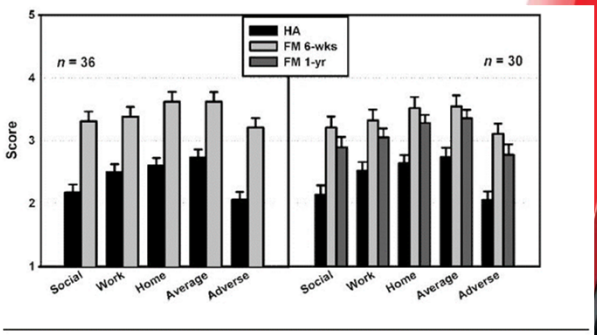

Figure 4. Mean scores and standard errors for the Communication Profile for the Hearing Impaired (CPHI) subscales for hearing aid use alone (HA) and after 6 weeks and 1 year of FM use.

Figure taken from: Chisolm, T., Noe, C., McArdle, R., Abrams, H. (2007) Evidence for the Use of Hearing Assistive Technology by Adults: The Role of the FM System. *Trends in Amplification.* 11(2): 73-89.

Is it just down to goal setting?

- **Not exactly!**
- Chisolm study participants were veterans in the VA system, meaning cost was a non-factor
  - Though they did rate the FM System as having a high value
- Chisolm studies focused on perceived benefit of the technology
- Chisolm's participants were also thoroughly counseled
  - Oral, written, and hands-on demonstrations were standard throughout these studies
  - Specific to goals set by participants
- In our cases, we had one subject with tangible goals and one with minimal/no tangible goals
  - Setting goals can help patient define success and make benefits tangible
  - Achieving goals determined success, Case Closed…right?
- **Again, not exactly!**
- Transparency and SNR benefit need to be ensured
- Counseling may also be key
- In our cases, while counseling was provided, more counseling may be needed
  - Providing written and hands-on demos may aid in success

Translating research into a clinical fitting strategy

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Establishing the FM patient road map

- Include both objective and subjective measures
- Road maps will likely be different based on the patient
  - No two paths are the same, even if the patients look similar on paper!
  - 3 Main focuses to be included in each road map

1) **<u>Set goals early</u>**
   - Goals help patient relate technology to real world and can help audiologist set realistic expectations
   - Need to be concrete, real world, and realistic goals
   - Can be scalable, can change as patients meet goals
   - Goals need to be addressed at follow ups
     - Not helpful if left in the chart and forgotten

Establishing the FM patient roadmap

2) **Performing FM Transparency Measures**
- Confirms patient will get improved SNR, access to desired sounds
- Real ear curves provide a counseling tool
- Provides baseline if patient has problems down the road
- You can't be sure unless you objectively measure!

3) **Provide Thorough, FM specific, Counseling**
- Concrete instruction using multiple methods (oral, written, visual)
  - Consider patient goals in instruction
  - Address patient concerns
  - Promote self-advocacy
- Consider the whole patient
  - Provide relevant counseling that is tailored to the patient
- **Patient success starts with you!**

FM Systems: Conclusions

- FM systems have proven benefit of increasing speech understanding and increasing SNR in noisy environments and at a distance
- Measuring and programming FM transparency should be performed to ensure patient receives expected benefit from the FM system
- Goal setting and providing adequate counseling and instruction on how to meet those goals is pivotal for patients to understanding how to qualify success and the best ways to achieve success with FM systems

Thanks for listening!

Questions?

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