Acceptance of the wireless microphone as a hearing aid accessory for adults

By David Fabry, Hans Mülder, and Evert Dijkstra

INTRODUCTION

In recent years, the rapid transition from analog to digital hearing aid technology has provided many improvements, including automatic and adaptive directionality, multichannel noise cancellation, feedback phase inversion, and acoustic scene analysis that automatically monitors and alters hearing aid program settings as a function of changes in the listening environment.[1,2] None of these advances, however, has produced speech-recognition benefits in noise or at a distance that exceed what has been possible for many years with FM wireless microphone technology.[3-6]

In fact, depending on signal-to-noise ratio and the speech-perception abilities of the individual with hearing loss, there are situations in which the individual with hearing loss can hear speech better in noise, using a wireless microphone, than can his normal-hearing counterpart.[6,7]

Despite these impressive findings, and despite a long history of educational use, adult market penetration of wireless microphone technology remains very low. In fact, current estimates are that FM systems are used by only 1 in 200 hearing-aid wearers.[8] Still, speech recognition in noise remains the "brass ring" of hearing aid technology, begging the question of why do so few adults seek wireless solutions when the results are so impressive?

BARRIERS TO FM/WIRELESS USE

There has been much speculation about why wireless technology has not gained greater market acceptance among adults. Possible reasons include:

- lack of clear-cut criteria for determining device candidacy
- inadequate counseling, instruction, and coaching of hearing aid users regarding FM use
- cost
- presumed complexity
- insufficient awareness of the possibilities on the part of dispensers, hearing aid users, and the public at large
- cosmetics and intrusiveness
- the difficulty of balancing the signals from the FM and hearing aid microphones.

Some of these barriers can potentially be overcome through technology. Others require systemic changes. Recent developments on both fronts provide reason for optimism regarding the acceptance and use of wireless technology by adult hearing aid users.

Candidacy

In their comprehensive study on veterans,[9] Noe et al. reported that subjective and objective communication benefits were observed for 36 subjects with an FM device when the following candidacy criteria were observed:

- at least moderate to severe sensorineural hearing loss
- demonstrated lack of satisfaction in at least one situation where FM might benefit, including difficulty hearing in small groups, large groups, places of worship, riding in a car, etc.
- commitment to a schedule that included time for adequate coaching, counseling, and instruction regarding FM use.

All 36 participants in the study elected to keep their devices. This decision could have been influenced by the fact that no cost was involved. A follow-up study, however, indicated that 30 of the 36 subjects were still using their FM systems 12 to 18 months post-fitting for an average of 6 hours a day, suggesting that they were still benefiting from wireless technology. Although it may be that many subjects would not initially "look a gift horse in the mouth," it is unlikely they would continue to be using the devices a year later if they were not truly receiving benefit.

Measures of speech recognition in noise have been gaining acceptance in the audiological community as a differential diagnostic tool for selection of directional microphones and wireless microphones.[10] Unlike audiometric thresholds or self-report data, measurement of signal-to-noise ratio (SNR) deficits provide objective data for patients and their families in listening situations that have high face validity.

The Quick Speech-in-Noise Test (QuickSIN[11]), Hearing in Noise Test (HINT[12]), Words-in-Noise (WIN[13]), and Bamford-Kowal-Bench Speech-in-Noise test (BKB-SIN[14]), to name a few, may be used by clinicians to assess candidacy for various microphone technologies on the basis of SNR deficits relative to normative data.

Table 1 contains a guide, based on the QuickSIN norms,[11] that has been promoted for use when determining candidacy for directional and wireless microphones.[10] Note that this is only one component of a clinical test battery that also includes audiologic evaluation and clinical needs assessment.

Counseling

As discussed elsewhere in this issue, Chisolm and her colleagues provide key evidence that counseling and instruction are essential for successful outcomes with wireless products.[15] This is, in part, due to the complexity of operation of current devices, and will continue to be an obstacle for many who are either not "early adopters" of new technology or are

Table 1. *Table, based on QuickSIN,[11] for assessing candidacy for directional-microphone and FM technology.*

SNR Loss	Category	Technology Needs
0 - 2 dB	Normal	Omnidirectional microphones
2 - 7 dB	Mild	Fixed/Adaptive directional mics
7 - 15 dB	Moderate	Adaptive/Fixed directional mics
> 15 dB	Severe	FM system

not extremely motivated to seek benefits in noisy listening environments.

Individualized follow-up and self-instruction are possible, via strategies like Listening and Auditory Communication Enhancement (LACE) training,[16] which will improve clinical efficiencies and appeal to the time-crunched baby boom generation. Additional research is required, however, to see if this self-paced approach provides similar success rates to those achieved by Noe et al.[9] Note also that recent years have seen reductions in complexity--from the user's perspective--and that these improvements are likely to continue, perhaps reducing the need for extensive coaching. The goal is to achieve the kind of simplicity that, in the computer industry, is known as "plug and play."

Cost

Currently, integrated wireless microphone technology adds approximately 50% to the cost of binaural digital hearing aids. The use of Bluetooth technology, described elsewhere in this issue by Yanz and Preves,[17] has made a huge impact in the consumer electronics world as a means of providing two-way wireless communication between gadgets (e.g., a cell phone and wireless headset).

The cost of Bluetooth communication has dropped steadily since its introduction, and this technology offers exciting new possibilities for integration with hearing aid technology. Already, several hearing aid manufacturers have developed products that combine Bluetooth with dedicated FM technology to enable hearing aid wearers to use their hearing aids as hands-free cell-phone receivers.[18] This convergence of hearing aids and consumer electronic products will reduce stigma, simplify use, and lower costs.

That said, there are still some barriers to the use of Bluetooth alone as a primary means of audio communication for wireless transmission. Table 2 compares a few of the major differences between Bluetooth and systems that have been developed specifically for wireless applications with hearing aid users. However, as Yanz and Preves discuss in this issue,[17] many of these limitations will be resolved in the near future, helping to lower costs and increasing market acceptance.

Presumed complexity

The widespread application of Bluetooth communication would help reduce the challenges faced by the many consumers who find the use of FM confusing. Currently, using FM wireless microphones with hearing aids can require:

- a dedicated transmitter, with a fully charged battery
- the appropriate frequency channel selected to match that of the wireless receiver
- the wireless receiver attached to the BTE hearing aid, or a coded neck loop for use with ITE hearing aids
- the hearing aid switched to the appropriate program via selector switch or remote control (additional hardware required).

In some cases, this means that the hearing aid user has to carry up to three additional pieces of equipment (transmitter, receiver/neck loop, remote control) to engage and use wireless transmitters, providing a tremendous disincentive for those who are not gadget freaks. As a result, there is a great need to simplify the operation of these devices via:

- integration of the FM receiver into BTE and ITE devices. If there is a wireless receiver in every device, it can be enabled or disabled by the clinician as an option rather than requiring an additional piece of hardware.
- simplifying the operation of wireless devices by incorporating advanced hearing aid features, such as datalogging and acoustic scene analysis. These features have proven useful in improving clinical efficiencies by reducing the need for follow-up appointments by monitoring and applying changes in volume control settings made by individual users, automatically detecting the presence of a specific listening environment, and providing feedback regarding remaining battery life directly to the end user.
- placing wireless transmitters in public places, including theaters, movie theaters, places of worship, university classrooms, and assembly halls. The utility of having wireless receivers in every device would be realized further by using automatic detection, pairing, and activation of wireless transmission when a person enters the room. Bluetooth appears ideal for this purpose, as it provides a (relatively) widespread standard for use in public address systems at a low cost.

Lack of awareness

A public awareness campaign similar to

Table 2. *Comparison of dedicated FM with Bluetooth.*

	Dedicated FM	Bluetooth
Radio Frequency	216...217 MHz (primary use for ALD)	2.4 GHz (used for headsets, etc.)
Power consumption	2 mA @ 1V = 2 mW	20 mA @ 3V = 60 mW
Range	> 100 feet	< 30 feet
Audio bandwidth	7.5 kHz	3.4 kHz (headset profile) 10 kHz (audio profile)
Latency (delay)	< 2 ms	> 10 ms (headset profile) > 100 ms (audio profile)

the "Got Milk" campaign used by the dairy industry could be instrumental in explaining the advantages of universal wireless transmitters in public places for use with hearing aids equipped with the receivers. This should be a multidisciplinary campaign involving hearing aid manufacturers, manufacturers of electronics equipment, entertainment facilities, professional associations, and consumer advocacy groups.

One way to increase awareness might be to develop a brochure or advertising campaign advising hearing aid users to "Ask your audiologist about wireless microphones."

Cosmetics

Generationally, baby boomers have already demonstrated that they are not likely to be as stigmatized by hearing aids as their predecessors, as evidenced by the myriad of Bluetooth headsets that resemble large BTE devices in current use.[18] That said, baby boomers wouldn't use them if they didn't work effectively.

Although the performance of FM technology in public places has never been questioned, their style has until recently been rather uninspired. The introduction of "micro" BTE devices that look and feel "edgy" compared with traditional "institutional" hearing aids could be a prelude to hearing aids evolving into "personal communication systems."

An associated problem is that of intrusiveness. Some hearing aid users may be reluctant to ask a talker to wear a microphone. Although this problem may best be addressed though counseling, improvements in design could also play a role.

Balancing FM and hearing aid microphone signals

A major obstacle with all wireless microphone technology is the issue of how to position the microphone close enough to the primary source to optimize SNR without interrupting the normal flow of conversations and interactions when multiple talkers are present. A partial solution is to have the hearing aid microphone active at the same time. But, unless the two are carefully balanced, there is a danger of reintroducing all the noise that the wireless microphone was designed to eliminate.

One prospective solution enables several microphones to multiplex with a single receiver to facilitate simultaneous conversations between multiple persons via wireless technology.[19] This is already possible with dedicated FM systems, but with some increase in cost and complexity.[20] Another option is Bluetooth. Currently, up to seven active devices can be paired within a "piconet" network, but processing delays increase with the number of paired devices for acoustic signals, resulting in a noticeable delayed auditory feedback effect in some cases.

Other solutions involve dynamically adjusting the FM advantage on the basis of surrounding noise levels to optimize SNR while still allowing audibility of sounds via the hearing aid microphone.[4,20] When paired with effective adaptive directional hearing aid microphones, this type of system may provide maximum FM advantage without compromising hearing aid effectiveness, a requirement for any assistive technology if it is to be truly effective.[21]

SUMMARY

We are on the cusp of a wireless revolution. When the technology meets the expectation, we will have reached a tipping point and change will occur quickly. The combination of generation effects, systemic changes, component miniaturization, and developments in low-cost consumer electronics will all contribute to furthering adult acceptance of the wireless microphone as a hearing aid accessory.

As discussed in this article, the primary sub-goals to be met in order to improve ACCESS to sound via wireless microphones include:

- Awareness by hearing aid users, the dispensing community, and the public at large that this technology exists and is highly effective
- Candidacy requirements that are clearly established
- Cost reduction
- Ease of use in both private applications and public places
- Smart design to improve cosmetics, reduce intrusiveness, and simplify operation
- Support and counseling before, during, and after the fitting/purchase.

David Fabry, PhD, was formerly Vice-President of Professional Relations and Education at Phonak Hearing Systems, Warrenville, IL. Drs **Hans E. Mülder** is director of FM Marketing, and ir **Evert Dijkstra** is Managing Director, both at Phonak Communications AG, Murten, Switzerland. Readers may contact Dr. Fabry at dfabry@med.miami.edu.

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