Terminology and Standardization

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Introduction

With the significant changes in FM technology in the past few years, the need for standardized terminology has increased. In addition, procedures for electroacoustic, real ear, and behavioral assessments with FM technology have been recommended by the American Speech, Language, and Hearing Association and some of these have been incorporated into test sequences of portable hearing aid evaluation system. Exchange of information regarding the performance of various systems would be facilitated by the use of common terminology. Therefore, the purpose of this presentation is to present a taxonomy for FM hardware, features, and measurement protocols. Following a brief review of the rationale for using FM Systems and the history of FM standardization efforts, a taxonomy is presented for FM devices and measurement protocols. Results from the interactive polling support the development of such a system. The proposal reviewed here is presented as a stimulus for further discussion and modification by participants.

Rationale and Historical Overview

Most would agree that the benefit of using FM Systems is to improve the signal-to-noise ratio (SNR) which can result in improved speech recognition. In contrast, there is less agreement regarding the terminology used to describe these systems and the procedures used to measure their benefit. Given that a major problem for persons with hearing loss is listening in noise, a common rehabilitative goal is to achieve an optimal signal-to-noise ratio. In general terms, the person with impaired hearing wants to hear the primary message referred to as the "signal" at an intensity level that is greater than the unwanted sounds referred to as "noise." The greater the intensity of the message relative to the noise, the more positive the SNR and the easier the listening task becomes. Although there are many ways to achieve the positive SNR through environmental manipulations or instructions to the speaker, one optimal way is through the use of an FM System. This is especially helpful when environmental manipulations may not be possible such as reducing noise from air condition systems. Ideally, the listener would experience not only a positive SNR but also a constant signal level regardless of distance.

A typical FM System involves an FM Transmitter and microphone for the speaker and an FM Receiver for the listener. The FM signal can be delivered to the user via soundfield speakers, interface with a personal device such as a hearing aid or cochlear implant, or through an earphone/headphone set. Within each of these broad categories there are numerous options to consider. The choice of system may depend on user constraints such as the inability to interface with a personal hearing aid, instructional constraints where the movement to many teachers or centers throughout the prohibits a wall-mounted soundfield system, and/or financial constraints which often require that the greatest amount of equipment be purchased for the greatest number of students. The variety of options results in possible variations in SNR received by the user and highlights the importance of standardized procedures to compare benefit across systems.

Unlike the standards for the evaluation of

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hearing aid performance (ANSI S3.22, 2003), there is no document approved by the American National Standards Institute (ANSI) for the evaluation of Assistive Listening Devices. A working group, ANSI S3/WG81, initially devoted a significant amount of time to defining the scope of the standard. It was determined that it would be called "Specification of Hearing Assistance Devices/Systems" (HADS) and address those systems that were packaged for individual use as opposed to systems used in large areas such as theatres. Although a draft was completed in 1997, during the approval process the FM technology changed so rapidly that the draft standard became quickly outdated. Therefore, a revision is needed which addresses the currently available ear-level FM technology.

In America, the document that is referred to in the absence of an ANSI standard is the Guidelines For Fitting and Monitoring FM Systems (ASHA, 1999). The American Speech, Language, and Hearing Association Ad Hoc Committee that developed the Guidelines included Arthur Boothroyd, Dawna Lewis, and Barbary Murphy. The Guidelines include recommendations for personnel, preselection, management orientation, monitoring, and fitting and adjustment. To date, the ASHA Guidelines provide the most direction and represent the consensus in the field in America. Although specific information is provided, standard terminology for the variety of devices available today is not included. Furthermore, suggested measurement procedures could be simplified through the use of abbreviated terminology similar to that used with real ear measures (REUR-Real Ear Unaided Responses or RESR-Real EAR Saturation Response). Therefore a taxonomy will be proposed to address FM Devices and FM Evaluation. The suggestions provided here are limited to FM Systems that accept acoustic input to a microphone and deliver an electric or acoustic signal to a user. Furthermore, the suggestions are provided here as stimuli for a more elaborate system. They are not intended to comprise a complete system of documentation for all available options, but simply an example to stimulate thought and initial agreement regarding the value of having an acceptable taxonomy system.

Classification of FM Devices

Because the most successful labeling schemes involve familiar terms, this taxonomy for FM Devices will be referred to as the TLC system. This refers to the notion that devices are described by their Type, Location, and Channel options. To begin the TLC taxonomy, one may consider how the three general categories for options can be applied to the FM Transmitters, as well as the FM Receivers. For each of these categories, one may ask a question, the answer to which defines the characteristic for that category. Ideally, when the characteristics for each category are determined, the three descriptions would yield a useful acronym that would facilitate their recognition. This is analogous to the adopted system to completely describe a hearing loss by three general characteristics: the slope, degree, and type. The proposed TLC system for FM Transmitters and FM Receivers is shown in tables 1 and 2, respectively.

The first question to ask for the FM Transmitter Type would be "What are the directional characteristics of the microphone?" The possibilities as shown in figure 1 are: Omni-directional Microphone (OM),

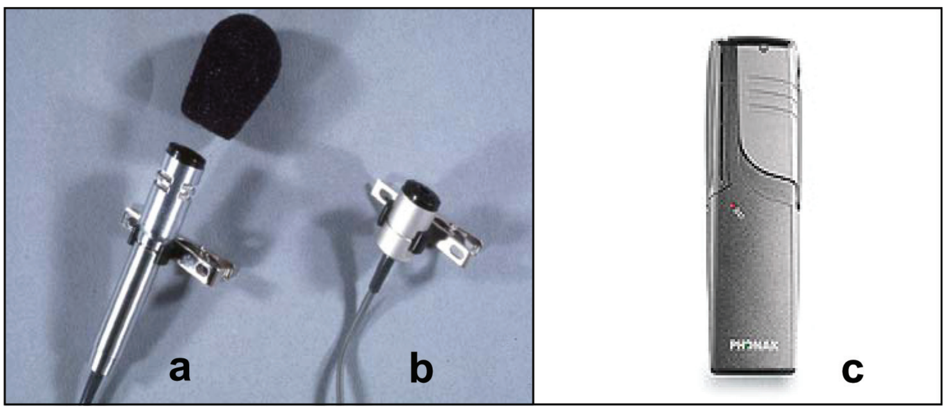

Figure 1. Options for FM Transmitter Microphone type include a) Directional (DM), b) Omni-directional (OM), and c) Multi-directional (MM). Photo of MM courtesy of Phonak Hearing Systems.

Table 1. Type, location, channel selection (TLC) taxonomy for FM Transmitters

Type		Location		Channel Selection	
Omni-directional	OM	On the Body	OB	Fixed Frequency Selection	FFS
Directional	DM	Head Band	HB	Manual Frequency Selection	MFS
Multi-directional	MM	Lapel Clip	LC	Direct Frequency Selection	DFS
		At the Cheek	AC	Active	+

Note: Acronyms are listed to the right of the term.

Table 2. Type, location, channel selection (TLC) taxonomy for FM Receivers

Type		Location		Channel Selection	
Basic Arrangement	BA	On the Body	OTB	Fixed Frequency Selection	FFS
Personal Arrangement	PA	At the Ear	ATE	Manual Frequency Selection	MFS
				Wireless Frequency Selection	WFS
				Direct Frequency Selection	DFS
				Automatic Frequency Selection	AFS

Note: Acronyms are listed to the right of the term.

Directional Microphone (DM) and Multi-Directional Microphone (MM). The first two, OM and DM, may be distinguished by additional microphone ports on the side that allow sound coming from the side to be reduced relative to that entering from the top. The MM is also characterized by multiple ports with a user-controlled switch to adjust the sensitivity to sounds from a broad radius of 180 degrees to a more narrow range of 25 degrees directly in front of the listener.

The second question would refer to FM Transmitter Microphone Location. Although all FM Transmitters are worn on the body, one may ask "What is the location of the FM Microphone?" The possibilities include: On the Body (OTB), Head Band (HB), Lapel (LC) and At the Cheek (ATC) as shown in figure 2. The location is defined by how the microphone is positioned on the speaker with the HB and ATC providing the closest and the most consistent positioning to the speaker's mouth. Optimal proximity and stability are desirable for maximum intelligibility of the FM transmitted signal.

For the third category, one may ask "What are the Channel Options?" There are two general possibilities: Fixed Frequency Selection (FFS) or Multiple Frequency Selection, which can be further subdivided into Manual Frequency Selection (MFS) or Direct Frequency Selection (DFS). As shown in figure 3, the FFS allows for only a single transmission channel that is hardwired and cannot be changed. When multiple frequencies are an option, the transmission channel can be varied by manually exchanging a frequency oscillator, MFS, or by directly tuning in the channel through adjustments on a digital display or trimpots, DFS. The DFS FM Transmitter, shown in figure 3, could be considered an "Active" system which would be one that is capable of sending a signal to synchronize the channel with an FM Receiver. This

Figure 2. One option for wearing the FM Microphone is "At the Cheek" (ATC). Photo courtesy of Phonak Hearing Systems.

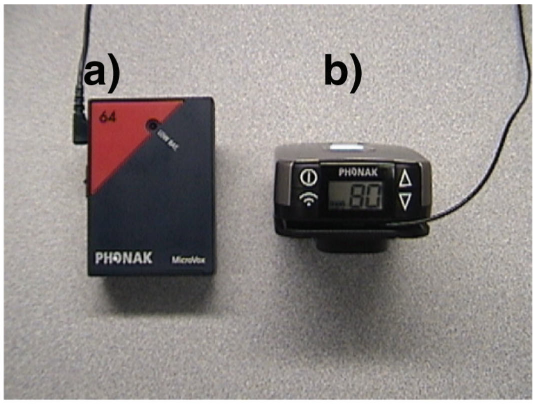

Figure 3. Two of the options for FM Transmitting Channels include a) Fixed Frequency Selection (FFS) as shown from the front, and b) Direct Frequency Selection (DFS) as shown from the top.

could be designated by a "+" following the DFS designation.

To illustrate the application of the TLC Taxonomy, a Phonak TW3 Transmitter will be described. Given the three basic categories Type, Location, and Channels, it could be categorized as a MM, OTB, MFS Transmitter. It has a **M**ulti-directional microphone, is worn **O**n the Body, and it has **M**anual Frequency Selection. The starting frequency of the transmitting range might also be added to designator. For example, to facilitate quick comparison across manufacturers, one may call this a **MOM**/216 Transmitter, an acronym which is based on the first letter of each of the three descriptive characteristics and the possible starting frequency. Application of the TLC Taxonomy to the Phonak Campus S transmitter would result in the **DAD+/**216 transmitter. That is one which has a DM, **D**irectional Microphone, worn ATL, **A**t the Lapel, and with DFS, **D**irect Frequency Selection. Another example would be the Phonic Ear Lexis FM Transmitter which would be a MM, OTB, DFS or MOD/216 Transmitter. It is not capable of sending the signal to a receiver to synchronize the channel.

Recall that this taxonomy is an initial proposal for stimulation toward further discussion, perhaps by interested committees and task forces of professional organizations. There certainly are several other options not addressed in this proposal that may characterize an FM Transmitter such as programmability, audio input jacks, battery indicator lights, and talk over or mute switches. However, in an effort to propose a scheme that is relatively simple to facilitate recognition and hopefully initial acceptance, the taxonomy is limited to three major characteristics.

To apply the TLC taxonomy to the FM Receiver one may consider the Type referring to the relationship with the personal amplification system, the Location again referring to whether it is worn on the body or at ear level, and the Channel Selection referring to the Fixed or Multiple Frequency options. To define the options as shown in table 2, one may ask the first question "Does it interface with a personal system, i.e. one that is worn throughout the day?" If it does not interface with a personal system, it could be called a Basic Arrangement (BA); whereas if it does interface with a hearing aid or cochlear implant that is owned by the user, it could be called a Personal Arrangement (PA). The Basic Arrangement would include a variety of coupling options such as a button earphone, headphone, Soundfield speaker, or a "FM Amplifier."

This term "FM Amplifier" is relatively new term which refers to the use of a behind-the-ear hearing aid to deliver the FM signal to the user as well as the environmental sounds. For school districts to upgrade to the FM Receivers that attach to behind-the-ear hearing aids while having control over the interface and not relying on the student's personal aid, a decision may be made to purchase "FM Amplifiers" for all students. This results in an efficient system for the educational audiologist who can easily maintain the systems because of the homogeneity and lack of dependence on equipment maintained by individual families. Proposals to purchase "FM amplifiers" are often more acceptable to administrators than the purchase of "hearing aids." With the FM Amplifier arrangement, the student comes to school and removes the personal hearing aids and uses the school-purchased ear-level FM Amplifiers with the FM Receiver attached. Unlike the Basic FM System, the Personal FM arrangement includes interfacing with the user's personal hearing aid through use of a neckloop, silhouette, or direct audio input connection.

The next question would be "Where is it worn?" The choices at this time are limited to On the Body (OTB) and At the Ear (ATE). The final question to characterize the FM Receiver according to the TLC system is "What are the Channel Options?" Again the possibilities include the Fixed-Frequency Selection (FFS) or the Multi-Frequency Options which can be divided into Manual Frequency Selection (MFS) or Wireless Frequency Selection (WFS). With FFS, the frequency of the FM Receiver is fixed and cannot be

Figure 4. One type of Wireless Frequency Selection (WFS) is Automatic Frequency Synchronization (AFS) which causes the FM Receiver to automatically change to the set channel when the student walks within three feet of the wall panel shown on the left. The wall panel is shown on the right. Photos courtesy of Phonak Hearing Systems.

changed by the user. However, in some cases, the channel of the FFS Receivers may by altered by returning the system to the manufacturer for a modification. For the MFS Receiver, the channel would be changed by manually exchanging the oscillator. For the WFS Receivers there are two ways in which the channel can be changed, Direct Frequency Selection (DFS) and Automatic Frequency Selection (AFS) as shown in figure 4. With DFS, the FM Receiver must be within a close range of the FM Transmitter that is sending the channel, and the change occurs when the button is pushed on the transmitter. The AFS system involves a wall pad that contains a transmitter that is continually sending the signal to change the frequency such that as persons walk by the channel is changed automatically. This AFS system could be a significant advantage in situations where students are changing classes frequently during the day. As with the transmitters, the starting frequency of the FM range could be added to the acronym.

To apply the TLC system to an FM Receiver, consider the Phonak MicroVox RX2 COM-1 when used with a neckloop and personal hearing aid. This FM Receiver would then be a Personal Arrangement, On the Body, Manual Frequency Selection System, or POM/216. The MicroLink MLxS Receiver could be classified as a Personal Arrangement, At the Ear, Wireless Frequency Selection, or PAW/216. Although similar, the Phonic Ear Lexis Receiver would be a Personal Arrangement, At the Ear, Fixed Frequency Selection System, or PAF/216.

There are other options for the FM Receivers that are not included in this simplified scheme. Once a terminology system is accepted and becomes as familiar as other audiologic acronyms such as behind-the-ear (BTE) hearing aid or real-ear-aided-response (REAR), the other FM Receiver options may be added to the system. These could include options for programming the ratio of the FM signal to the environmental one, audio input jacks, indicator lights, or environmental microphones.

One terminology issue that is not specifically

Figure 5. Suggested use of the labels a) "boot" and b) "shoe." The single-component arrangement where the FM Receiver is hard-wired to the component that fits on the base of the BTE could be referred to as the "boot" and the two-component system where the FM Receiver attaches to the component that then attaches to the base of the BTE aid could be referred to as the "shoe." Photos courtesy of Phonak Hearing Systems.

addressed in the TLC system is the use of the labels "shoe" and "boot." These are generally used to refer to attachments to the BTE hearing aid to secure a connection to an FM Receiver. One proposal is to use the term "boot" when the FM Receiver is hard-wired to the connection that fits on the bottom of the BTE because it resembles a "boot" as shown in left side of figure 5. The term "shoe" could refer to the cup-like component that attaches to the base of the BTE as show in the right side of figure 5. To be more precise, the two kinds of shoes need defining. There are direct-audio-input (DAI) shoes which simply allow for an electrical connection from another powered source to the hearing aid such as the DAI connection of a personal FM System. There are also FM Receiver shoes which allow for an electrical connection in such a way as to provide a power source from the hearing aid to the FM Receiver. Depending upon the purpose, the correct audio shoe (DAI or FM Receiver) must be used.

The interactive polling was used to determine the consensus of those attending the conference. For the FM Receiver that is hard-wired to the connection (left side of figure 5), 71% agreed with the proposed term "FM Receiver Boot." For the attachment to the hearing aid that secures the FM Receiver to the aid (right side of figure 5), 62% agreed with calling it an "FM Receiver Shoe" and 26% preferred the term "audio shoe." These results suggest that professionals are ready to designate these terms for specific components which should facilitate discussion regarding research as well as funding proposals for new equipment.

As the use of FM Systems by persons with Cochlear Implants increases, the need for consistent terminology becomes more important in order to facilitate comparisons across sites and manufacturers. The TLC system for FM Transmitters and Receivers would still be applicable. In general, the delivery of the FM signal through the FM Receiver to the cochlear implant may occur through one of three ways which include audio, electrical, or inductive coupling. The audio coupling simply involves the use of an FM Receiver that is coupled to a loudspeaker, either wall- or desktop-mounted. The electrical coupling may involve using patch cords or direct plugin to connect

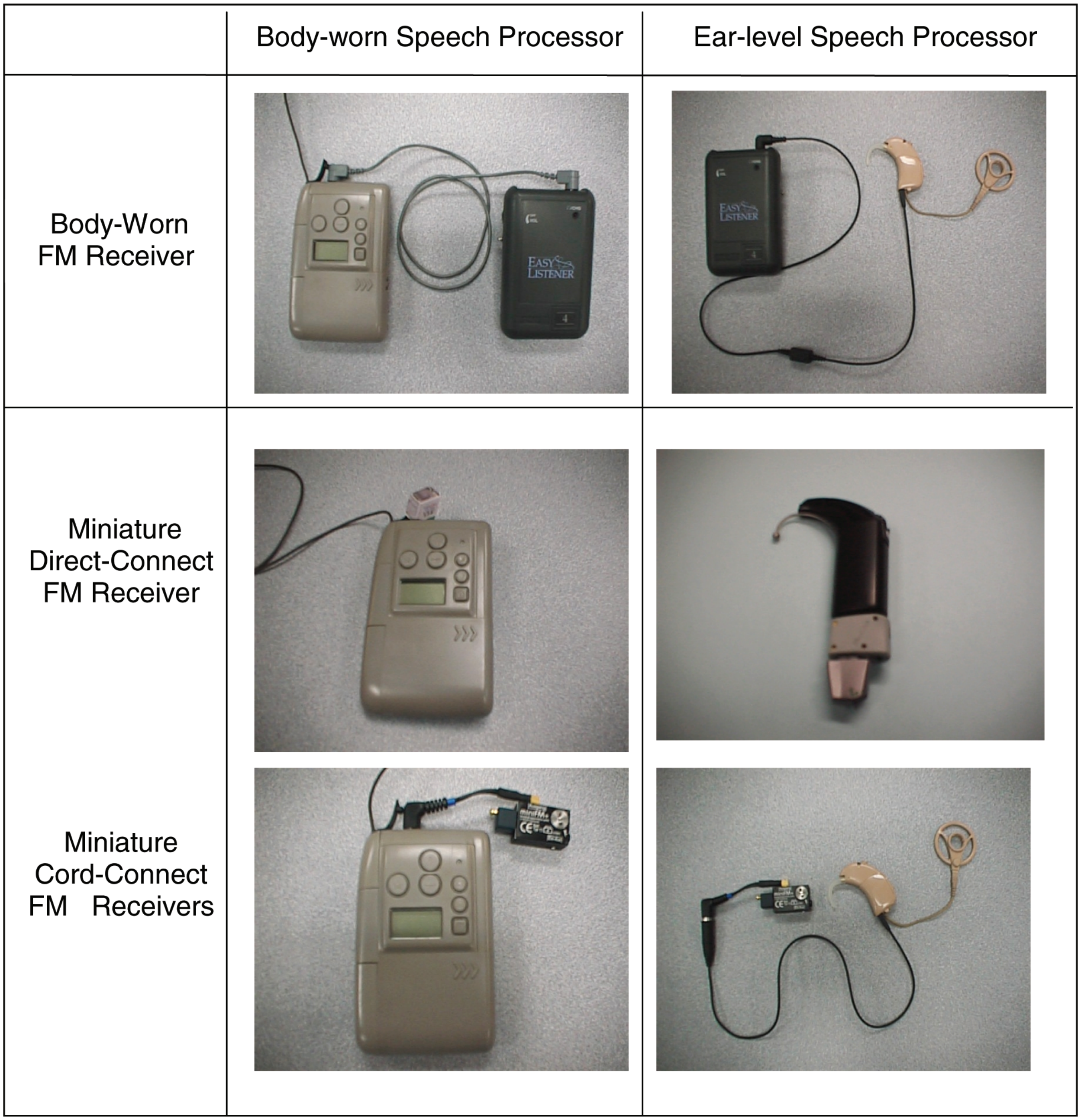

Figure 6. Possible direct electrical connections with body-worn (left side) and ear-level (right side) cochlear implant speech processors and with body-worn (top section) and ear-level FM Receivers (bottom section).

the FM Receiver to the speech processor. The possible combinations of ear level and body-worn systems for

Cochlear Implants and FM Systems are shown in figure 6. The final option to signal delivery is the use of T-Coil Coupling which requires that the cochlear implant speech processor have a T-coil and the FM Receiver deliver the signal via a Neckloop.

FM Evaluation Procedures

Just as important as having consistent terminology to refer to the FM Devices is having consistent terminology to refer to measurement procedures. There are three general types of measurements with FM Devices which include electroacoustic, real ear, and behavioral procedures. The ASHA Guidelines (1999) address all three procedures, and the following proposed terminology is based on those recommended measures. In general, the recommended measures involve comparing responses obtained via the amplification settings or some type of environmental microphone to those responses obtained via the FM settings or some type of FM microphone. This discussion will be focused on the proposed terminology for the electroacoustic and behavioral measurements. For these proposals, it will be assumed that the hearing aid is appropriately fit, and these measures are being performed to optimize an FM System relative to an optimally-fit hearing aid.

For the electroacoustic and real ear measures, one may think of two sets of curves, one done with typical signal input levels and another done with maximum signal input levels. The purpose of the first set of measures is to evaluate the response of the systems with levels that simulate the signal levels encountered in actual use conditions to ensure that audibility is maintained through the FM System an optimal signal-to-noise ratio is obtained. The purpose of the second set of measures is to evaluate the response of the systems with intense signal levels to ensure that the FM System does not result in significantly higher or lower maximum output than the amplification system did prior to connection with the FM System. From these two measures, one can observe the dynamic range over which the speech signal will be delivered to the listener.

The first set of curves may be referred to as the FM Advantage set. The ASHA Guidelines recommend evaluation with 65 dB SPL complex signal input to the microphone of the hearing aid and 80 dB SPL complex signal input to the microphone of FM Transmitter. The 65 and 80 dB SPL inputs simulate the average speech levels arriving at these microphones in typical use situations. The second set of curves may be referred to as the FM Transparency set and is obtained using a 90 dB SPL swept pure tone. This input signal allows for measurement of the saturation response of the hearing aid and the FM System.

In order to efficiently describe these curves a system is proposed to indicate the measurement procedure and input level. This system will be illustrated with an OLF/216 FM Transmitter and a PAF/216 FM Receiver. The first designator of the evaluation taxonomy will refer to the type of measurement: "E" for electroacoustic measures, "R" for real ear measures, and "B" for behavioral measures. Then the next designator will indicate the microphone that is receiving the input: "HA" for hearing aid, "FM" for FM System when set to FM only, and "FM/HA" when set to receive FM and environmental signals. When in the FM/HA mode, it is important that the testing is done in a relatively quiet environment. The final designator will be the signal level in dB SPL: 65, 80, or 90. Just as the profession has adopted REUR, REAR, REIR, REOR, and RESR to refer to measurement procedures with probe microphone systems and amplification, the system shown in table 3 may prove useful to compare measures across laboratories and device combinations. An example of the associated equipment setup for these recommended measurements is shown in figure 6. The electroacoustic measure of the FM Advantage

Table 3. Proposed terminology for referring to electroacoustic measures with hearing aids and FM Systems.

Designator	Type of Measure	Microphone to Receive Input	Signal Type	Signal Input in dB SPL
EHA65	Electroacoustic	HA	Complex	65
EHA90	Electroacoustic	HA	Pure Tone	90
EFM80	Electroacoustic	FM	Complex	80
EFM90	Electroacoustic	FM	Pure Tone	90
EFM/HA80	Electroacoustic	FM while HA Mic is Active	Complex	80
EFM/HA90	Electroacoustic	FM while HA Mic is Active	Pure Tone	90
EHA/FM65	Electroacoustic	HA while FH Mic is Active	Complex	65
EHA/FM90	Electroacoustic	HA while FM Mic is Active	Pure Tone	90

Note: HA=Hearing Aid, FM=Frequency Modulated, Mic=Microphone

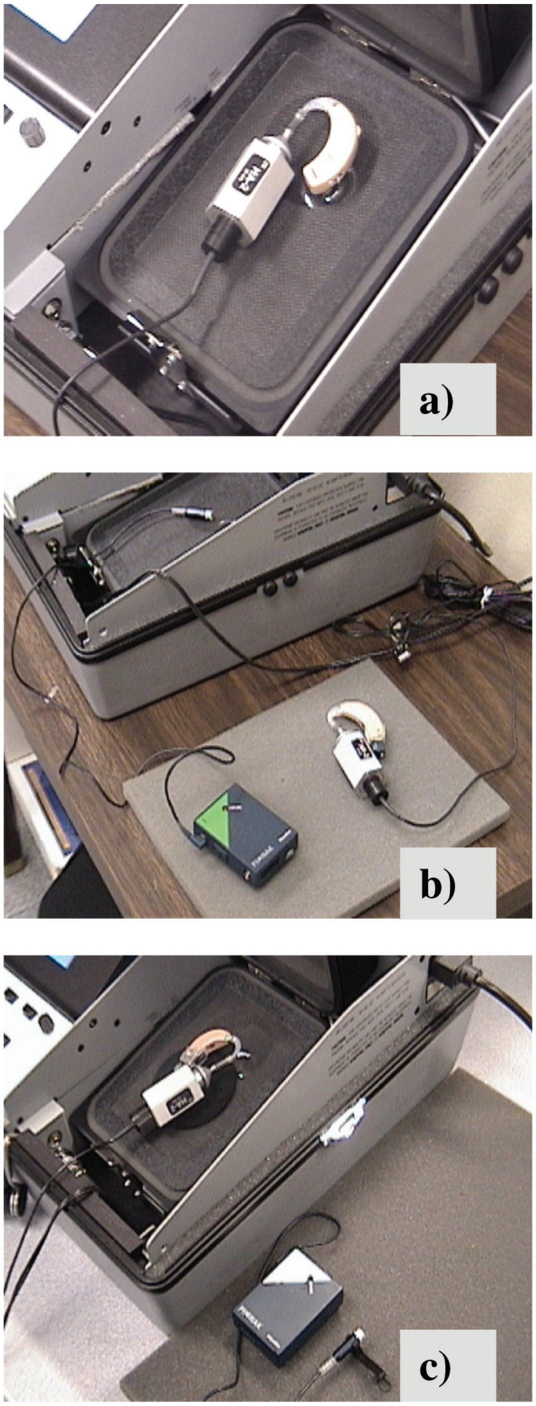

Figure 7. Equipment setup for testing a) EHA65 and EHA90, b) EFM80, EFM90, EFM/HA80, EFM/HA90, and c) EHA/FM65 and EHA/FM90.

(EFMA) would be determined by subtracting the EHA65 from EFM80 or EFM/HA80 curves. The ASHA guidelines recommend that the EFMA should be 10 dB. The electroacoustic measure of the FM Transparency (EFMT) would be determined by subtracting the EFM90 or EFM/HA90 from the EHA90 curves. Ideally the EFMT would be 0 dB, that is the maximum output of the FM System would match that of the HA system. If it is a positive number, that would suggest that the HA has a higher maximum output and the FM System is resulting in additional limiting of the signal. However, a negative EFMT would suggest that the FM System has greater output which could cause concern if the hearing aid is optimally fit.

A possible sequence for obtaining these measures with the OLF/216 Transmitter and the PAF/216 Receiver for a system when both HA and FM microphones are active would be to first measure the response when there was input to the hearing aid alone as shown in figure 7a to obtain EHA65 and EHA90 curves. Then connect the FM System and measure the response when the input is directed to the FM microphone in the combined FM and HA mode as shown in figure 7b to obtain EFM/HA80 and EFM/HA90. Then finally, measure the response when the input is directed to the HA microphone in the combined FM and HA mode as shown in figure 7c to obtain EHA/FM65 and EHA/FM90.

Three curves which can be compared to determine the electroacoustic FM Advantage (EFMA) are EHA65, EFM/HA80, and EHA/FM65 as shown in figure 8. The EFM/HA 80 curve is approximately 10 dB higher than the other two curves which suggests that the listener would receive the FM signal at a positive SNR. This would result in an optimal EFMA. Another example to illustrate both the Electroacoustic FM Advantage (EFMA) and Electroacoustic FM Transparency (EFMT) is shown in figure 9. In this case, the EFMA is optimal only in the high frequencies, however, the EFMT is very acceptable across the frequency range. When the desired EFMA and EFMT are not obtained, adjustments may be necessary to the FM System first, if possible, and second to the hearing aid. These adjustments may include manual tuning of trimpots or digital programming of either the hearing aid or the FM Receiver. The programming may occur through the traditional NOAH interface or a dedicated system for the FM Receiver such as the Phonic Ear Programmer for the Sprite FM Receiver or the Phonak Toaster for the Synthesized MicroLink Receiver. The toaster, shown in figure 10, is connected to the computer through the NOAH interface and allows for adjusting the level of the FM

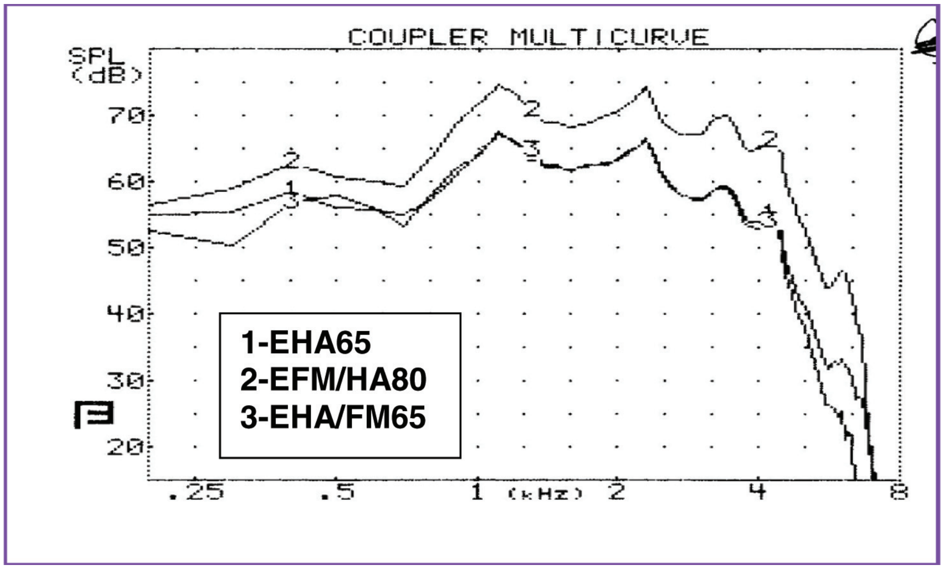

Figure 8. Electroacoustic measures of a hearing aid and FM System showing an approximate 10 dB advantage when the EFM/HA80 curve is compared to the EHA65 or EHA/FM65.

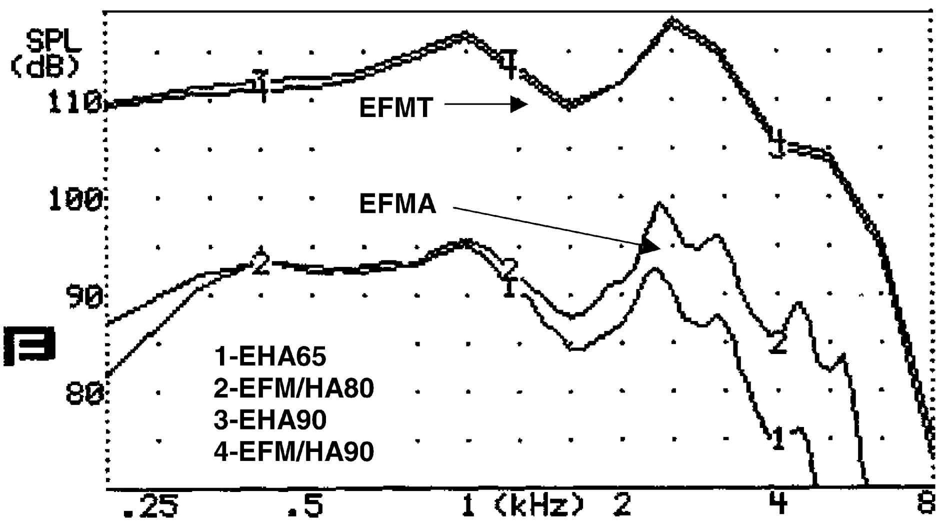

Figure 9. Electroacoustic measures of a hearing aid and FM System showing EFMA only in the high frequencies and EFMT across the frequency range.

signal as well as setting the default frequency of the synthesized FM Receiver.

The electroacoustic verification procedures can now be applied to cochlear implants with direct electrical or inductive connections to FM Systems. When the cochlear implant allows the attachment of a monitoring earphone simultaneously with the FM Receiver, the relative output of the system just prior to the electrode array can be examined. At this time, only the Nucleus 3G and Sprint Processors allow an earphone to be attached at the same time as the FM Receiver. Figure 11a shows monitoring headphones and Phonak MicroLink FM Receiver attached to a Nucleus 3G and a Sprint Cochlear Implant. The output of the earphone can be measured using the hearing aid test system microphone and a half-inch to one-inch adapter as shown in figure 11b. A thorough testing protocol has not been established, but two preliminary measurements are suggested to verify the FM signal is being received through the speech pro-

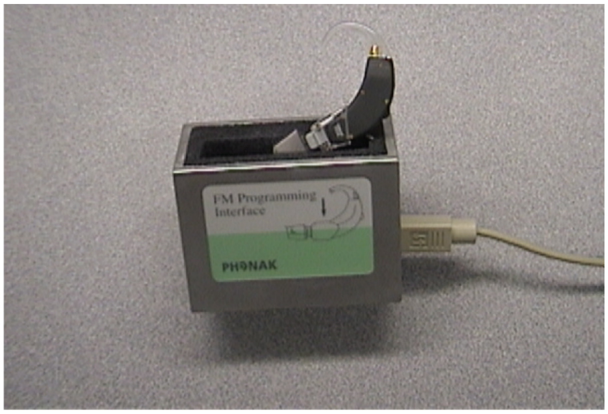

Figure 10. The Phonak Toaster allows for programming the level of the FM signal and setting the default channel of the FM Receiver.

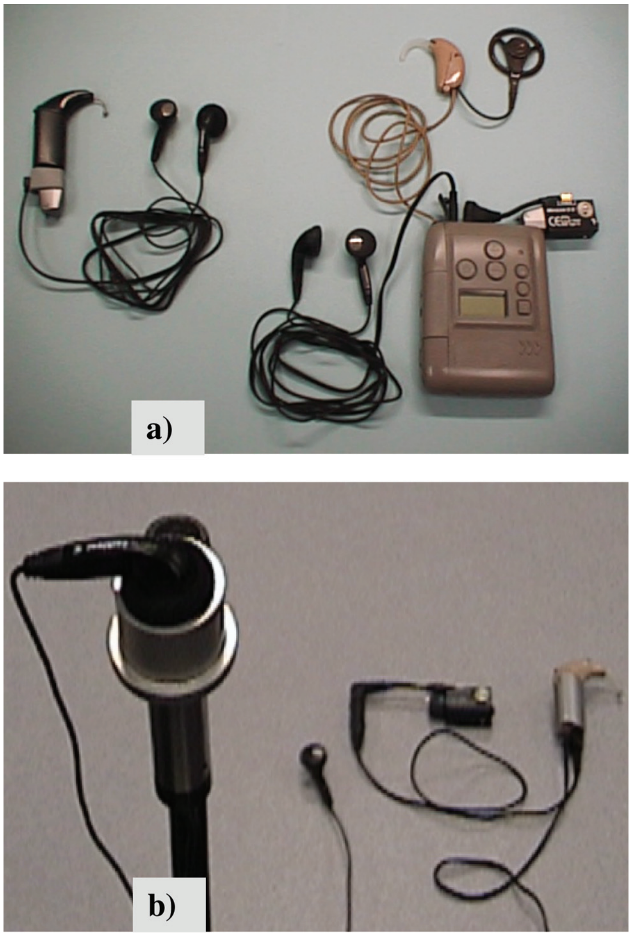

Figure 11. Equipment arrangements for the electroacoustic measurement of output from a) a monitoring earphone and Phonak MicroLink attached to a Nucleus 3G (left) and Sprint (right) cochlear implant, using b) a hearing aid test system microphone inserted into a half-inch to one-inch adapter.

cessor and observe some relationships regarding the audio mixing of the signals from the speech processor microphone and the FM Transmitter microphone. The measurement procedures resemble those recommended for the electroacoustic evaluation of the hearing aid and can be referred to using analogous terms. A possible sequence for conducting these measurements is to first obtain ECI/FM65 by placing the speech processor in the test box with lid open so that the directional microphone is facing speaker output. A 65-dB SPL, complex signal is presented to the speech processor microphone while the FM System is attached and active but placed outside the test box in a relatively quiet environment. The rms output from the earphone is recorded rather than the frequency response because it is the relationship of signal level that is important rather than the output at specific frequencies. Next the EFM/CI80 FM Transmitter microphone is placed in the test box and the speech processor remains on and outside the test box. The rms output from the earphone is recorded while an 80-dB SPL, complex signal is delivered to the FM Transmitter Microphone. A higher value for EFM/CI80 than for ECI/FM65 suggests that the signal received from the FM Transmitter would be delivered to the electrode array with greater intensity than that from the speech processor microphone, i.e., an FM Advantage. The controls on the speech processor may be manipulated to alter this FM Advantage if they are programmed to vary microphone sensitivity.

The ASHA guidelines (1999) also address verification of FM fittings with real ear measures and with behavioral measures. The terminology for each of these can follow that established for the electroacoustic procedures and will be discussed here for the behavioral testing situation because professionals are often asked to demonstrate the benefit of the FM System in the Soundbooth. The behavioral verification involves speech recognition measures rather than threshold testing because of difficulties relating the threshold measurements obtained at low signal input levels to the performance of the system at typical signal input levels that often much higher (ASHA, 1999). In general, speech recognition is assessed while wearing the hearing aid alone and then with the FM System, in background noise intended to simulate typical environments, and in quiet if time permits. It is assumed that the listener would be receiving the combined FM and Environmental signals when using the FM System. Speech recognition materials with multiple, equivalent lists that are appropriate for the listener will be needed. The listener is seated in the Soundbooth with the hearing aid set to user settings. The examiner is outside the test booth with the FM Transmitter and microphone in place as typically worn, but turned off. In order to simulate the typical inputs to the microphones of each system, the testing is done via monitored live voice.

Following the same terminology system, the first test would be BHA55, where speech is presented to the listener in quiet at 55 dB HL. The next test would be BHA55/50 where speech is presented at 55 dB HL and speech noise is presented at 50 dB HL, resulting in a +5 SNR. This should result in a significant decrease in performance. If not, the noise may be increase to cause performance to decline so that the FM benefit in the next step may be observed. The next measure, BFM/HA55/50, is performed with the FM System is turned so that the listener hears the examiner through the FM microphone and through the loudspeaker while the noise remains on at 50 dB HL. The speech recognition score should increase significantly over BHA55/50. If not, adjustments are necessary so that the FM signal is received at a higher level than that received through the hearing aid microphone. Finally, if time permits, the BFM/HA55 condition can be assessed where the FM remains on, but the noise is turned off. If score increases significantly, then FM gain was probably too low to allow maximum FM benefit.

To illustrate the application of these test procedures, the results from a third grader who resisted wearing the FM System with his bilateral hearing aids are reported. For BHA55, he was able to repeat 90% of monosyllabic words. When noise was added for BHA55/50, his score fell to 60%. With the addition of the FM System and bilateral FM Receivers, his BFM/HA55/50 score was 90%! Removing the noise but still listening through the FM System resulted in a BFM/HA55 score of 100%. Although the performance may easily be described with linguistic terms, the use of the acronyms may assist the professional in efficiently recording the results and comparing results across test sessions.

The behavioral testing may be readily applied to children using cochlear implants as illustrated by the results obtained with a eight-year old using a Nucleus 22, SPRINT Speech Processor and a Comtek PR72B FM System. The first two measures through the cochlear implant alone, BCI55 and BCI55/50, resulted in 96% and 32% correct scores, respectively. When the FM System was added, the BFM/CI55/50 score was 80%, which suggested that the student was receiving significant benefit from the FM Receiver that was electrically connected via a patch cord to the cochlear implant speech processor.

Summary

The need for standardized terminology is supported by the growing diversity among FM Options. The proposed system is a starting point for future discussion. The intent of the TLC system was to provide a simple format with a mnemonic to facilitate recall of the three general categores: type, location, channel. When the conference participants were polled regarding the three category system, 74% either moderately or strongly agreed. This result would support the further discussion to refine the system for maximum usefulness. Regarding the need for a standard for the evaluation of FM Systems, 90% moderately or strongly agreed. Such universal agreement strongly supports the immediate need for the ANSI Working Group to reconvene to revise the draft proposal of 1997. Given the rapid-changing technology, there will no doubt be ongoing revisions as is the case with the standard for the electroacoustic evaluation of hearing aids. Hopefully, the proposals presented here will facilitate the discussion and movement towards a standard for the evaluation of FM Systems in the near future.

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