The deleterious effects of noise, distance, and reverberation on listeners with hearing loss, including those with minimal and unilateral loss, have been documented for more than 30 years (e.g., Bess, Klee, & Culbertson, 1986; Boney & Bess, 1984; Crandell, 1993; Finitzo-Hieber & Tillman, 1978; Hawkins & Yacullo, 1984; Johnson, Stein, Broadway, & Markwalter, 1997; Ross & Giolas, 1971; Russetta, Arjmand, & Pratt, 2005). For example, Finitzo-Hieber and Tillman reported that children with hearing loss exhibited poorer speech perception than did peers with normal hearing in various conditions of noise and reverberation. Crandell compared sentence recognition in noise for children with minimal hearing loss (15 dB HL–30 dB HL) and children with normal hearing. Children with minimal hearing loss performed more poorly at most signal-to-noise ratios (SNRs), with differences across the groups increasing as the SNR decreased. Johnson et al. examined consonant and vowel identification in nonsense syllables for children (6–14 years) with high-frequency hearing loss, age-matched children with normal hearing, and adults with normal hearing. To better reflect typical listening conditions, testing was completed in both quiet and noise (+13 dB SNR) in a classroom with a reverberation time of 0.7 s. In both conditions, vowel and consonant identification were better for adults than for either group of children. Interestingly, the children with high-frequency hearing loss demonstrated significantly poorer consonant identification than did the children with normal hearing in quiet but not in noise. There was no significant difference between the two groups for vowel identification in either condition. These results suggest that, in quiet, the children with normal hearing were able to access high-frequency information that was not available to the children with high-frequency hearing loss. However, in noise, high-frequency information was no longer audible to the children with normal hearing, and their scores decreased to a level that was similar to that of their peers with hearing loss.

As shown in Table 1, some groups of children with normal hearing also may be negatively impacted by the effects of distance, noise, and reverberation (e.g., Bradley & Sato, 2004; Crandell & Smaldino, 1996; Finitzo-Hieber & Tillman, 1978; Jamieson, Kranjc, Yu, & Hodge, 2004; Johnson, 2000; Nelson, Kohnert, Sabur, & Shaw, 2005; Zentall & Shaw, 1980). For example, Zentall and Shaw (1980) compared the performance of hyperactive and control children on classroom tasks in the presence of background noise with a high linguistic content (to represent typical classroom listening conditions). For a familiar task, the hyperactive children were more active and performed more poorly in high levels of noise than did the control children. For a new task, both groups performed more poorly in high levels of noise. Nelson et al. compared speech perception in quiet and noise for second graders who were monolingual English speakers and second graders who spoke Spanish in the home and learned English as their second language (L2). Although both groups performed more poorly in noise than in quiet, the L2 group was more negatively impacted by the noise.
In most classrooms, the ability of students to hear and understand verbal information is critical to learning. However, this ability is compromised in many schools because of poor classroom acoustics. In classrooms, background noise can be considered any unwanted sound that interferes with the primary signal (e.g., the teacher's voice, the voices of other students, the audio signal from an instructional CD or DVD). Noise can originate from sources outside the school building (e.g., traffic, children on the playground), sources inside the building but outside the classroom (e.g., students in the hallway, a nearby gym class), or sources in the classroom (e.g., heating and air conditioning systems, noises made by the students themselves).

The American National Standards Institute (ANSI) Working Group on Classroom Acoustics has recommended maximum steady background noise levels of 35 dBA and maximum reverberation times of 0.6 s (ANSI, 2002) for typical, medium size classrooms. However, many classrooms fail to meet these criteria. Finitzo (1988) reported background noise levels in a variety of unoccupied classrooms ranging from 35 dBA to 47 dBA. When the rooms were occupied, the levels ranged from 40 dBA to 73 dBA. Interestingly, noise levels in one uncarpeted classroom for students with hearing loss (5 students and 1 teacher present) were higher (60 dBA–67 dBA) than levels in a traditional classroom with 25 students and 1 teacher (58 dBA to 60 dBA). More recently, Knecht, Nelson, Whitelaw, and Feth (2002) evaluated background noise levels and reverberation times in 32 elementary classrooms in three different school districts. Noise levels ranged from 34 dBA to 66 dBA, with only four classrooms having noise levels below the ANSI-recommended levels. Reverberation times ranged from 0.2 s–1.27 s, with 13 classrooms exceeding the ANSI recommendations.

The audibility of speech in a classroom also is affected by the fact that the distance between the listener and talkers (teacher, other students) varies throughout the day. This affects not only the absolute level of the signal reaching the listener’s ears, but also the level of that signal relative to background noise in the classroom. The overall level of a teacher’s voice 1 m from the listener is approximately 71 dB SPL (Pearsons, Bennett, & Fidell, 1977). However, as distance between talker and listener varies, as will happen throughout the school day, the overall level reaching the listener’s ears also will vary. Using the Rapid Speech Transmission Index (RASTI), Leavitt and Flexer (1991) examined the integrity of a speech-like signal at various seating positions in a classroom relative to a sound source at the front-center of the room. A score of 1.0, representing perfect reproduction of the signal, was obtained only at the reference position (6 in. from the sound source). Other values ranged from a high of 0.83 in the front row center seat to 0.55 in the back row. Although there is not a one-to-one correspondence between the RASTI score and speech perception, these findings demonstrate that the signal reaching the ears of students in classrooms is far from ideal.

One solution to the problems of noise, distance, and reverberation would be for the talker to remain in very close proximity to the listener at all times. Such a solution clearly is not possible or practical in today’s classrooms, where the issue is complicated by the fact that traditional row-style seating and lecture-style teaching often have been replaced by diversified methods of teaching (e.g., individual, small group, large group), which impact student teacher proximity throughout the day. However, it is possible to reduce the distance from the teacher to the student by placing a microphone close to the teacher’s mouth and sending the signal to a remote receiver that amplifies and/or brings the signal close to the student’s ears. Classroom amplification systems generally are designed to do just that by maintaining the level of the primary signal (e.g., the teacher’s voice) at a constant level above the background noise. These systems also can be connected to audio sources within the classroom such as televisions or computers to provide auditory access across a wide range of listening activities. The remainder of this article will address two of the most commonly used options in classroom amplification: individual frequency modulated (FM) systems and sound-field systems (FM and infrared).

### TABLE 1. Populations of children with normal hearing sensitivity who may experience difficulties understanding speech in adverse listening environments.

<table>
<thead>
<tr>
<th>Population</th>
</tr>
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<tbody>
<tr>
<td>Attention deficit disorders</td>
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<tr>
<td>Auditory processing disorders</td>
</tr>
<tr>
<td>Developmental delays</td>
</tr>
<tr>
<td>Dyslexia</td>
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<tr>
<td>English language learners</td>
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<tr>
<td>Recurrent middle-ear dysfunction</td>
</tr>
<tr>
<td>Speech and language disorders</td>
</tr>
<tr>
<td>History of conductive hearing loss</td>
</tr>
<tr>
<td>Hyperactivity</td>
</tr>
<tr>
<td>Young children</td>
</tr>
</tbody>
</table>

Individual FM systems consist of a microphone/transmitter that is worn by the talker and a remote receiver that may be coupled to the listener’s ear in a variety of ways. Microphones typically are worn on the chest (lapel mic), 6–8 in. from the mouth; or on the head (boom or cheek mic), within 1–2 in. of the mouth; or around the neck (collar mic). The signal is transmitted by FM radio waves to a receiver that is worn by the listener. Current microphones/transmitters are much lighter and more comfortable to wear for longer periods of time than were earlier versions. As such, they may be more acceptable to classroom teachers. Older students also may benefit from the use of handheld transmitters with multiple options for directionality of the microphones. These transmitters place control of the microphone with the listener and may be useful in listening environments where they can be pointed toward the sound source (e.g., during a small-group activity, at lunch).

FM systems with self-contained body-worn receivers were introduced in the mid to late 1960s (Ross, 2008). Early receivers were coupled to the ear via a button transducer and usually had limited options for control of
frequency response and output. Over time, more adjustability became available, allowing these systems to be used with individuals with widely disparate degrees and configurations of hearing loss. In 1982, behind-the-ear (BTE) transducers were introduced for use with self-contained FM systems (P. Henry, personal communication, May 30, 2008). Although these transducers looked like BTE hearing instruments, they were connected directly to body-worn FM receivers via cords and used the controls on the body-worn devices to set frequency and output characteristics.

Body-worn personal FM systems that were coupled directly to an individual’s hearing instrument(s) via direct audio input or induction neckloops/silhouettes were introduced in the early 1980s (P. Henry, personal communication, May 30, 2008). Over time, these systems also were coupled to lightweight headsets. Because they were designed to be coupled with hearing instruments, personal FM systems did not have internal controls other than a volume control. Figure 1 illustrates coupling options for body-worn FM receivers.

Body-worn FM systems often were considered bulky and cumbersome, limiting their use beyond classroom environments. Moeller, Donaghy, Beauchaine, Lewis, and Stelmachowicz (1996) conducted a 2-year longitudinal study of home use of self-contained body-worn FM systems. They reported the following:

Difference in size and number of components between traditional hearing aids and FM systems was one of the biggest deterrents to FM system use in this study. Both parents and subjects in the FM group reported that the system was bulky, often uncomfortable, and cumbersome to use in some situations outside the home. Parents expressed concern about potential breakage or cord entanglement when their children were climbing or running. A common situation such as shopping for clothes increased in complexity when the child was wearing an FM system. Because the FM system was more visible than the child’s personal hearing aids, parents also reported more obtrusive looks and comments from strangers. Children in the FM groups became more self-conscious as they matured and often protested FM system use in public places. (Moeller et al., 1996, p. 37)

Although parents and children reported benefit from the FM systems as assistive devices in difficult listening situations, none chose them as primary amplification at the end of the study.

The first BTE FM/hearing instrument combination was introduced in 1992 (Sonovation, 2008). Early instruments were the size of large BTE hearing instruments and incorporated an external antenna (Figure 2).

Before 1996, BTE FM/hearing instruments, operating in the 72–76 MHz frequency range, needed external antennas to allow adequate transmission distances between the FM transmitter and receiver for use in typical listening situations. However, in 1996, the Federal Communications Commission approved additional FM channels in the 216–217 MHz bands (Federal Communications Commission, 1996). As a result, FM manufacturers were able to further miniaturize receiver antennas without detrimental effects to transmission distance.

The new transmission frequencies introduced in 1996 allowed manufacturers to remove external antennas on BTE receivers. With miniaturization of receivers, the next advance in FM systems that was introduced was a miniature FM

![Figure 1. Coupling options for self-contained and personal body-worn frequency-modulated (FM) receivers.](image-url)

receiver, which could be coupled directly to BTE hearing instruments (Phonak, 2008a). The first generation of miniaturized receivers could only be coupled to one manufacturer’s hearing instruments (Figure 3).

However, in 2000, a miniaturized universal FM receiver was introduced, which could be connected to most brands of hearing instruments via direct audio input (Figure 4). Over time, universal FM receivers have continued to decrease in size, allowing them to fit more comfortably on even very young children.

The miniaturization of FM receivers has had a tremendous impact on the extension of FM system use beyond classroom environments. FM systems can, for example, be used in extracurricular activities such as sports, dance, or drama. Students involved in after-school jobs or in volunteer organizations can use the systems to improve communication access in a variety of adverse listening environments. The ability to couple a small FM receiver to a personal hearing instrument or to have the FM receiver incorporated into a BTE hearing instrument case makes utilization in a variety of listening environments much more feasible and attractive to users.

Miniaturization of FM receivers also resulted in changes in FM systems for use by individuals with normal or near-normal hearing, including those with auditory processing disorders. Before the availability of ear-level receivers, lightweight headsets were coupled to body-worn FM receivers. Although headsets provided an open fitting for normal-hearing ears, they could be uncomfortable when worn for long periods of time and were distracting for some students. Some of the first mild-gain ear-level receivers looked like hearing instruments and could be coupled to open-fit earmolds. Recent models have been designed to look less like hearing instruments and can be worn without earmolds (Figure 5).

Advances in FM technology have continued to improve the flexibility, adaptability, and convenience of FM systems for users. The first miniaturized FM receivers were single channel and had no means of adjusting the output characteristics of the receiver for individual users. The introduction of multifrequency miniaturized FM receivers combined with multichannel transmitters allows easy channel selection as users move from one listening environment to another. Thus, children who are working in small groups using different channels can be changed easily to a single channel...
for large-group activities. Teachers in different classrooms can have specific channels to which children’s receivers are set as they enter the classroom. Channel changes may be initiated from the teacher’s transmitters or, as demonstrated in Figure 6, channels can be switched automatically as the student enters the room.

The development of FM-level adjustability for miniaturized FM receivers has meant that they can be set to meet the listening needs of different users and can be adjusted as listening needs change. Recent advances in FM technology include alerting lights on receivers and programming capability on transmitters, as well as technology to reduce noise at the FM transmitter, adjust for varying voice levels, and compensate for microphone placement (Oticon, 2008). In addition, automatic FM adjustability, datalogging, advanced features for multiple talkers (e.g., team teaching), automatic adjustment features, and monitoring capabilities have been introduced recently (Phonak, 2008b). As advances continue, FM systems should be viewed as an integral part of an audiologist’s solutions for meeting the communication needs of individuals with hearing loss.

SOUND-FIELD AMPLIFICATION SYSTEMS

Sound-field amplification systems generally consist of a microphone/transmitter, amplifier, and one or more loudspeakers placed at strategic locations in a room (Figure 7). The goal of sound-field systems is to amplify the signal 10–15 dB throughout the classroom. When this goal is met, sound-field amplification systems can provide an improved SNR for all students in the classroom. In addition, they may result in a lower incidence of vocal problems (and fewer missed days) for teachers who do not need to raise their voices to the extent necessary in an unamplified classroom. Currently, classroom sound-field systems use either FM or infrared transmission signals. Although the mode of transmission is the same as with individual FM systems, FM sound-field systems typically use different frequency bands. Infrared sound-field systems send the signal from the transmitter to the receiver via infrared light. The signal is then amplified and sent to loudspeakers within the room.
As radio frequency and electromagnetic interference have negatively impacted the use of FM transmission in some areas, infrared systems have become a popular sound-field alternative. In addition, because infrared light does not transmit through classroom walls, there is no chance that signals from one classroom will interfere with those in other classrooms. However, light sources such as natural sunlight may interfere with infrared transmission, which can impact their use in some environments. In addition, the infrared light path from transmitter to receiver must not be obstructed during use.

Concerns have been expressed regarding the potential for poor quality signals if sound-field loudspeakers are not placed appropriately in a room (Flexer, 1992; Lewis, 1994). As a result of poor placement, sounds could be distorted or signal level might vary at different locations in the room. The reader is referred to Smaldino, Crandell, and Flexer (2005) for a review of issues related to the placement of sound-field systems in classrooms.

Benefits of sound-field systems have been reported for numerous populations, including students with minimal hearing loss, students with fluctuating hearing loss from middle-ear dysfunction, and children with normal hearing who have special listening needs, such as those listed in Table 1. (See Gegg Rosenberg, 2005, for a comprehensive review.) Early work examining the benefit of sound-field systems came from the Mainstream Amplification Resource Room Study (MARRS; Ray, Sarff, & Glassford, 1984; Sarff, 1981), a 3-year longitudinal project comparing the performance of children (Grades 4–6) with minimal hearing loss who had learning deficits but normal learning potential. Half of the children were placed in amplified classrooms where sound-field systems were used an average of 3 hr per day, and half were placed in unamplified classrooms. Although both groups showed gains in reading, language arts, and total composite scores on achievement tests, the greatest and most rapid improvements in academic achievement, particularly in reading, were seen for the children in the amplified classrooms. Neuss, Blair, and Viehweg (1991) compared word recognition in noise for children with minimal hearing loss who were using either hearing instruments or sound-field systems. Results revealed a small but statistically significant benefit for sound-field amplification over hearing instruments; performance was better for both when compared to the unaided condition.

Because students do not have to wear a receiver, sound-field systems may be more acceptable and compliance may be less of an issue than with individual FM systems. In addition, sound-field systems may be less intimidating for classroom personnel because there are fewer parts to monitor and maintain and equipment breakdowns are easier to identify than with individual FM systems. Financially, sound-field systems may result in a lower cost per student when compared to individual FM systems because one system is used to amplify an entire classroom.

Battery-powered desktop FM systems are a variation of sound-field systems where a small loudspeaker is placed close to the listener (Figure 8). They often have been used for individuals with cochlear implants during the period after initial hookup when the user may need additional classroom amplification but is not ready to be fitted with an individual FM system, or for cochlear implant users who are unable to provide information about the quality of signal received with an individual FM system. Desktop systems also have been considered as an option for students who are unwilling to wear individual FM systems but for whom large-area sound-field systems do not provide adequate amplification. They also may provide more flexibility than large-area systems because they can easily be moved from one classroom to another throughout the school day. As with individual FM systems, however, desktop systems may raise cosmetic concerns for some students because they draw attention to the individual, as opposed to large-area sound-field systems, which may be considered more “anonymous.”

Despite the many benefits of large-area sound-field systems, they may not be the most appropriate classroom amplification option for all listeners. For children with more severe degrees of hearing loss, sound-field systems may not provide enough amplification relative to the...
listener’s degree of hearing loss. Using four classroom amplification conditions, Anderson and Goldstein (2004) examined perception of sentences in noise for 8 children from 9 to 12 years of age with congenital mild to severe hearing loss who were binaural hearing instrument users. Amplification conditions included hearing instruments only, infrared sound-field systems, desktop FM systems, and personal FM systems. Results revealed no improvements in speech perception for sound-field amplification over that obtained with hearing instruments alone. Performance with desktop and personal FM systems was not significantly different across these two conditions and was consistently better than with either hearing instruments or sound-field systems.

Anderson, Goldstein, Colodzin, and Iglehart (2005) examined speech perception for 28 school-age children with hearing loss ranging from mild-to-moderate to profound. Twenty-two of the participants wore hearing instruments, and 6 wore monaural cochlear implants. Testing was completed with personal amplification alone, sound-field FM system, desktop FM system, and individual FM system. Results revealed no benefit of the sound-field system over that of personal amplification alone. Both desktop and individual FM systems did provide benefit over personal amplification, with no significant difference between these two options.

In a study of children using cochlear implants, Iglehart (2004) examined the speech perception of 14 school-age children under three amplification conditions in noise: no sound-field system, a wall-mounted sound-field system, and a desktop FM system. In addition, testing was completed in both a classroom with poor acoustics and a classroom with ideal acoustics. In the acoustically ideal classroom, although performance was better with both wall-mounted and desktop sound-field systems than with no amplification, there was no significant difference between amplification options. However, in the acoustically poor classroom, performance with the desktop FM was better than with the wall-mounted system which, in turn, was better than no amplification.

**SELECTION AND FITTING OF CLASSROOM AMPLIFICATION**

In order to recommend and fit classroom amplification systems, it is imperative that audiologists understand the rationale and procedures underlying the fitting and verification of these devices. Advances in all areas of hearing assistance technology have increased rapidly in recent years. In addition, it has become clear that decisions regarding the implementation of classroom amplification cannot be made without considering multiple factors beyond the degree and configuration of hearing loss. At the time of this writing, new clinical practice guidelines, “Remote Microphone Hearing Assistance Technologies for Children and Youth Birth–21 Years” (American Academy of Audiology [AAA], 2008a), have become available to address “eligibility, selection, and implementation of remote microphone hearing assistance technology (HAT), fitting and verification procedures, orientation and training with the device, validation and monitoring procedures” (p. 3).

The new guidelines address the listening needs of three groups of children and youth:

- **Group 1**: Children and youth with hearing loss who are actual or potential hearing aid users
- **Group 2**: Children and youth with cochlear implants
- **Group 3**: Children and youth with normal hearing sensitivity who have special listening needs

Because the process of selecting, fitting, and monitoring FM systems involves much more than knowledge of the degree of hearing loss, sections of the guidelines include:

- regulatory considerations
- personnel qualifications
- equipment and space requirements
- candidacy, implementation, and device selection considerations
- fitting and verification procedures
- implementation and validation procedures

A supplement to the guidelines (AAA, 2008b) provides verification procedures for ear-level FM systems. Later supplements will address verification for sound-field, desktop, and induction-loop amplification systems. In the supplement, fitting and verification procedures are individualized for each listening group. They include electroacoustic, behavioral, and real-ear verification.

The new verification procedures represent a significant change in recommended protocol when compared to the American Speech-Language Hearing Association (ASHA) “Guidelines for Fitting and Monitoring FM Systems” that were approved by that organization’s Legislative Council in 1999 (ASHA, 2002). The ASHA guidelines recommended a verification approach in which the output of the hearing instrument first was measured with a 65 dB SPL input and then the output of the FM system also was measured with a 65 dB SPL input. Output of the FM was adjusted to match the output of the hearing instrument (equal gain). Then, input to the FM was increased to 80 dB SPL and it was expected that the output of the FM would increase by at least 10 dB (FM advantage). If the FM advantage was not 10 dB, adjustment of the FM level was recommended.

In the days when hearing instruments (or the environmental microphone portion of a body-style FM system) used single-channel linear processing, this recommended procedure worked well. However, most current hearing instruments sold in the United States use some type of nonlinear processing, and many have multiple channels, with compression thresholds and ratios varying across channels.

At the time that they were developed, the ASHA guidelines provided the most current recommendations available. With changes in hearing instrument technology, as well as...
changes in FM technology, new verification procedures were needed. In addition, procedures were needed that would address fitting and verification of FM systems used by listeners with normal hearing as well as those coupled to cochlear implants. Thus, a reexamination of the evaluation and fitting process for FM systems was required (Eiten & Lewis, 2008). As discussed by Eiten and Lewis, there are a number of assumptions that guide current verification procedures:

- The gain and output of the hearing instrument to which an FM system is coupled has been adjusted appropriately. This assumption is important because the hearing instrument serves as the local microphone for the FM system.
- The FM signal will be adjusted to preserve an appropriate speech-to-noise benefit (typically 10 dB) when both the hearing instrument and the FM microphones are active.
- Test measures will be used that take into account the complex nonlinear characteristics of both the hearing instruments and the FM systems.

An important consequence of these nonlinear characteristics is that different input levels to the FM and hearing instrument microphones result in different compression and gain.

FM systems coupled to hearing instruments typically are used with the FM and hearing instrument microphones active simultaneously. However, current hearing instrument test systems do not allow simultaneous measurement of inputs to both the hearing instrument and FM microphones so measurements are made for each mode separately. If a verification approach uses different inputs to the FM and hearing instrument microphones (as in the ASHA guidelines), the compression characteristics resulting from high input to the FM microphone will make measurement of the FM response invalid when comparing it to that of the hearing instrument. In the AAA guidelines, a “transparency approach” to FM verification is recommended when FM receivers are coupled to hearing instruments. In general, a transparency approach uses a 65 dB SPL input to the hearing instrument microphone and a 65 dB SPL input to the FM microphone. If the FM level has been set for a +10 advantage, the output of the FM should not be different from the output of the hearing instrument by more than ±2 dB. If it is, adjustments to the FM level are made to achieve transparency (AAA, 2008a, 2008b).

When FM-only receivers are chosen for individuals with normal hearing, different verification procedures are required. FM-only fittings with open canals are coupled to FM systems. In the verification of FM-only fittings, two sound paths into the ear must be considered. A direct (unamplified) input pathway includes unamplified portions of the main talker’s voice, voices of other talkers, the user’s own voice, and background noise. An amplified input pathway is delivered from the FM receiver and provides a consistent input level of the main talker’s voice. However, because this is an open canal fitting, low-frequency portions of the amplified talker’s voice will “leak” out of the ear canal. Electroacoustic measures using a 2-cc coupler are not appropriate because they do not account for the acoustics in an open canal. Thus, real-ear verification procedures are recommended. Another important consideration when fitting individuals with normal or near-normal hearing is ensuring that maximum output of the FM system is appropriate. Real-ear measures also provide information regarding maximum output in the ear canal. The specific steps used for verification of FM-only fittings will depend on the real-ear test system being used. The reader is referred to Eiten (in press) and AAA (2008b) for specific details regarding verification procedures.

Behavioral verification is recommended as part (i.e., in addition to testbox and real-ear measures) of the fitting of FM systems both for individuals who wear hearing instruments and for those with normal hearing. For individuals who wear cochlear implants, however, it is the primary means of verifying FM performance. Behavioral verification is used to confirm that the FM system is functioning as expected for a given student. Although testing may be completed in quiet, priority is given to testing in the presence of noise as this more closely represents conditions under which the systems will be used. However, it is important to remember that clinical behavioral verification procedures may not be able to replicate specific listening environments. In all cases, performance is evaluated with no FM (i.e., hearing instruments alone, cochlear implant(s) alone, unaided) and compared to performance with the FM microphone active.

Currently, no guidelines exist for verification of sound-field or desktop amplification systems. Behavioral testing using speech perception measures with and without amplification in a clinical environment may be possible for desktop systems, but not large-area sound-field systems. Acoustics in some classrooms may negatively impact the benefit that can be obtained with large-area sound-field systems. Speech perception tests performed in the classroom with the system in place can provide useful information regarding benefits obtained with these systems.

Validation of Classroom Amplification

Following verification of FM performance, an important step in the process of fitting classroom amplification is validation. According to the Pediatric Working Group of the Conference on Amplification for Children With Auditory Deficits (1996), “the purpose of validating aided auditory function is to demonstrate the benefits/limitations of a child’s listening abilities for perceiving the speech of others as well as his or her own speech” (p. 56). Students, families, teachers, and administrative personnel should be provided with evidence that the amplification options that have been selected for a student are providing benefit by improving communication access. Validation is not a one-time event but is an ongoing process that includes both objective and subjective measures. As much as is possible, it should occur in and reflect the listening environments.
that the student will encounter. There are a variety of validation tools available for examining FM benefit, including self-assessments, observation questionnaires, functional evaluations, and educational evaluations. See the Appendix for a list of tools that may be used in the validation process. Although this should not be considered an exhaustive list, it does include a variety of tools. With the many tools available for validation, a structured method for selecting tools for a given individual is helpful. Lewis (in press) provides a discussion of the various categories of validation tools as well as a method that can be used to select specific tools. The selection method is based on a five-step approach that has been recommended by Cox (2005).

Kreisman, Crandell, Smaldino, and Kreisman (2005) presented information regarding a variety of outcome measurements with sound-field systems. Measurements included educational performance, acoustical measurements, functional assessments, speech perception tests, and acoustical formulae.

According to the AAA guidelines (2008a), implementation and validation of hearing assistance technology should include orientation and training for all individuals who will be using the system, both the child/youth and parents/caregivers/teachers. Once the device is being used, a monitoring plan should be developed to ensure that the device is functioning properly over time. These aspects of recommended practices are important and should not be overlooked when implementing classroom amplification.

**SUMMARY**

Advances in hearing instrument and FM technology provide audiologists and families with many choices when selecting classroom amplification. An understanding of the benefits and limitations of available options is important for audiologists who recommend and fit these devices. Of equal importance is an understanding of current fitting and verification procedures. Although the newest guidelines provide audiologists with the most current information, it is important to remember that verification procedures will continue to evolve as technology advances. It is vital that those entering the profession, as well as seasoned professionals, remain current in their knowledge and understanding of fitting and verification procedures. In addition, it is important to remember that the process does not end with verification. We must have procedures that allow us to ensure that the technology we have selected for an individual provides him or her with communication access that is appropriate for the listening environments that will be encountered. As those environments change, the ongoing process that is validation allows us to make any necessary changes in recommendations and/or technology so that we can continue to provide that access.

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APPENDIX. VALIDATION RESOURCES


