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## *Chapter 4*

# **BUILDING COLLABORATIVE TEAMS**

## **Whose Job Is It Anyway?**

The concept of a multidisciplinary approach to providing services to children with hearing loss has been well supported in the literature. For a comprehensive discussion of this topic, the reader is directed to Luetke-Stahlman and Luckner (1991). Once the presence of a hearing loss has been confirmed, additional personnel join the audiologist to form a team that includes, at the very least, a speech-language pathologist and a teacher of deaf children. Interestingly, the technology breakthrough represented by the cochlear implant created the impetus for the medical and educational communities to form a partnership unheard of in the past. The unique habilitative needs of an implant recipient after surgery allowed these two institutions to begin a dialogue to bridge the cultural gap that had long existed between hospitals and schools. With each institution focused on the goal of providing substantial auditory benefit to profoundly deaf children, the commonality of their goals blurred the lines of territoriality as the medical and educational communities joined forces. Because the notion of hospital-school collaboration is a relatively recent one, it must be acknowledged

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that some medical communities (as well as school communities) have had limited success in creating an interinstitutional collaborative team. Suffice it to say that it is always beneficial when an implant recipient receives services from a medical facility that respects the contributions of educational professionals; a school community that strives to reach out to the medical centers responsible for surgery and device management to invite open communication between the two.

A number of professionals who provide services to children with cochlear implants are from the speech and hearing community. Sometimes these individuals are hospital-based; others are school-based personnel. Additional professionals who see a child with an implant may be engaged in private practice; regardless of the personal affiliation of any of the child's team, it is key for these professionals to work collaboratively and not competitively. There is little utility in comparing performance outcomes by the child in one setting to another, especially when it is implied that services in one are superior to the other. When speech and hearing professionals work cooperatively and seek out strategies and techniques to encourage the child's best performance across settings, it is more likely that overall outcomes will improve. Sometimes a "competition approach" unwittingly develops between private practice and school-based professionals. Private practice SLPs are providing a service for fees with therapy sessions that are generally longer and more auditorily focused. More often, they do not have the multiplicity of assessment and instructional issues that face school personnel. Even within a school setting, there can be competition between the speech-language pathologist and classroom teacher. The classroom teacher may feel that the SLP has an advantage in postimplant habilitation because of the individualization of the "pull-out" session. Regardless, when the question is posed: "Whose job is it anyway?" (to help a child use the implant to achieve the highest possible outcomes for listening, language, and speech development) the answer is: "It's everybody's job." Each professional on the team has the general responsibility to help a child maximize the potential of the cochlear implant but also has specific responsibilities for which he or she is accountable. A closer look at the responsibilities of the school-based professional on any child's collaborative team may lead to a better understanding of how individual roles may be defined.

## **SCHOOL-BASED SPEECH-LANGUAGE PATHOLOGIST**

Among the responsibilities generally assigned to the school-based speech-language pathologist is the assessment of speech and language skills for the purpose of informing intervention. For children with implants, the SLP may also be charged with the task of assessing auditory skills using particular instruments designed for this purpose or through ongoing diagnostic therapy that will identify a child's strengths and weaknesses. The comprehensive picture of a child's skills and abilities that emerges from assessment enables the SLP to design and implement an intervention plan that encourages continuing development of listening skills, the vocabulary and syntax of English, and speech intelligibility. However, the school-based speech-language pathologist is the individual on the collaborative team who may serve in the greatest number of different roles. Children with cochlear implants may be found in placements ranging from special schools for deaf children who use implants to general education settings when mainstream placement for the child has been determined. At the former placement, the collegiality that exists between and among administration, faculty, and staff may make the workplace a stimulating one with all professionals operating under the same set of assumptions and working toward a common goal. On the other end of the placement continuum, SLPs in a general education setting may find themselves charged with a variety of additional roles. These include case manager, child advocate, device specialist, liaison with the implant center team as well as the family, and consultant to the classroom teacher(s). This leaves the SLP with little time for the critical auditory, speech, and language tasks normally assigned to this professional.

As case manager, the school-based SLP becomes the "go to" professional, especially when addressing the challenges awaiting children with implants in mainstream settings. Catapulted from novice to expert on the technology of the cochlear implant and the children who use them, many SLPs in mainstream settings are expected to hit the ground running after the child with an implant is assigned to their caseload. SLPs who find themselves as the sole individual responsible for children with cochlear implants should seek support through organizations affiliated with deafness and children who use implants. Finding a "mentor" or another SLP who

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has had experience in such a mainstream setting, may provide invaluable assistance in negotiating for and providing appropriate services to these children. Organizations such as AG Bell and the Network of Educators of Children with Cochlear Implants (see Appendix A) may be able to provide information and access to other professionals who will assist novice SLPs as they begin to work with implant recipients. One thing is certain, however; once a child with a cochlear implant enters an educational system, a number of additional professionals will “need to know” about the child’s skills and abilities. Therefore, SLPs in mainstream settings should make sure that they organize and catalogue all of the information distributed to teachers in year one, because the likelihood is great that the process will begin anew the following year with a new classroom teacher. Even when individuals attend a general in-service presentation, adult learning literature tells us that, unless there is the need for the direct application of the information, attention to, and recall of, the material is not of sufficient importance to warrant a commitment to fully process what is being presented.

Balancing the need to provide one-on-one auditory, speech, and language intervention directly with the necessity of offering indirect service through consultation to classroom (and other “specials”) teachers is a dilemma that faces many SLPs in mainstream settings. With only so many hours allotted to any particular child, the struggle to find the right combination of direct and indirect services may be daunting. One recommendation for getting the most out of therapy, while at the same time modeling strategies for the classroom teacher that encourage listening and language development, calls for the SLP to go into the classroom to provide services. Sometimes referred to as “push-in” or “collaborative” intervention, the therapist may actually team-teach a particular lesson with the classroom teacher or provide assistance to the child at his or her desk during a lesson by the teacher. When classroom teachers share instructional time with SLPs in the classroom, useful techniques that may prove to be beneficial to other children in the classroom (as well as the child with a cochlear implant) can be demonstrated and practiced. Of course, common planning time is essential to make collaboration worthwhile; however, the payoff for this investment may be well worth the difficulty in scheduling time for this activity within the school day. Even when the SLP assists the child individually (or within a small group that includes

peers from the classroom), there is a chance that the teacher will be able to observe and overhear some of the exchanges between the SLP and the child with an implant. This may be sufficient to begin a dialogue between the two professionals on the adoption of particular strategies that may enhance a child's performance in the classroom.

## **TEACHERS OF CHILDREN WHO ARE DEAF OR HARD OF HEARING**

In a manner similar to the school-based SLP, teachers of children who are deaf or hard of hearing (TOD) may find themselves in placements that span a continuum. These range from small instruction classrooms for children with hearing loss to mainstream settings where, as itinerant teachers, they provide services to children within a district but at many different locations. Teachers in small instruction classrooms generally have well-defined roles for working with children with implants. In addition to planning and implementing instruction for language and content, teachers are expected to provide opportunities for listening and talking during the school day to foster the development of spoken language. Attention to the development of clear and intelligible speech through the encouragement of carryover of skills practiced with the SLP may also be considered the task of a teacher in a small instruction classroom. Whether these classrooms are part of a school for deaf children or housed within a larger regional program, there are often clearly defined policies and procedures for working with implanted children. Teachers in more isolated, single class settings may find less administrative and supervisory guidance when it comes to designing programs for children with implants. Often, they are supervised by a special education professional who does not have direct experience with deafness. When teachers of deaf children with implants are in simultaneous communication (SC) programs or programs for deaf children that have traditionally been more oriented to manual communication, the challenge to create an environment that encourages audition and values spoken language may leave teachers feeling somewhat isolated from their peers. It is important for these teachers to seek the same kind of support recommended for the novice SLP: find other teachers who

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have successfully negotiated this new territory and profit from their experiences. Often, the mere validation of the difficulty of the task is sufficient to provide the motivation to persevere. The added benefit of sharing particular strategies and techniques will make the effort to network with teachers experienced in providing services to children with implants in SC settings worth the investment of time to locate them. Once again the reader is referred to Appendix A.

Perhaps one of the most challenging positions for working with children with implants is that of the itinerant teacher of deaf children. When children with implants reach the mainstream, their need for assistance and support varies widely. Even the most skilled implant users will require accommodations, and it is often the responsibility of the TOD to monitor the effectiveness of such accommodations. Children with implants who have made sufficient progress in small instruction classrooms to warrant mainstream placement will face new challenges there. The TOD may be called on to provide direct assistance to the child for a number of hours per day or per week. Sometimes this assistance takes the form of preteaching; at other times instruction may be reinforcing or remedial. The “degree of difficulty” of any district’s curriculum may influence the level of service provided to a child and the level of mastery that can be expected. Decisions to provide instruction on a breadth of topics will reduce the child’s opportunity to learn any one topic in depth. Sometimes helping a child learn how to explore one area of interest fully will be the wiser path to follow, but will result in less material covered overall. Like the SLP, the TOD may find a need to provide services to the child in the classroom and carve out time to consult with the classroom teacher for the purpose of information exchange. This affords the classroom teacher the opportunity to specify the areas in which the child needs specific assistance; the TOD can then impart a strategy or technique that might enable the child to be a more active participant during lessons. Of particular importance is heightening the classroom teacher’s appreciation of the complexities of the vocabulary and grammar of English as it relates to content instruction. Idiosyncratic gaps in word knowledge and unfamiliarity with certain syntactic structures of English may preclude an otherwise capable child of demonstrating comprehension of classroom discussion or text. Difficulty in answering test questions may occur as the result of misunderstanding the language of the question and

not a lack of content knowledge. As a specialist in the language needs of children with hearing loss, the TOD can call attention to the instances of complex grammar and challenging vocabulary in lessons and textbooks that may cause additional difficulty for the child with an implant in a mainstream classroom.

## **EDUCATIONAL AUDIOLOGISTS**

School-based audiologists are generally individuals who have specialized in pediatric audiology and have made a commitment to understanding the impact of hearing loss on learning in schools. Educational audiologists (EAs) can be found in schools for the deaf or regional programs and assume the responsibility for ongoing assessment and monitoring of the proper functioning of equipment used by children with hearing loss. Some schools specializing in working with children with cochlear implants are now providing mapping services for their students. For the most part, children still return to implant centers for their mapping. Some cochlear implant centers may send personnel into the schools to map children and may be assisted by the district EA. There are certain advantages to providing mapping on site and within the school day. The most obvious is the efficiency with which mapping can be performed along with the value of input from the various school personnel involved with the child with an implant. As larger numbers of children with implants enter district schools the role of the EA may expand.

Educational audiologists are also responsible for managing the use of personal FM systems with cochlear implant devices. This creates certain challenges for which the EAs have the most knowledge and skill from their years of experience with FMs and hearing aids. Managing the acoustic environment to ensure that it is advantageous for a child with an implant is also part of their role. For additional information about the use of assistive devices with a cochlear implant, the reader is directed to chapter 11.

Educational audiologists are knowledgeable about technology, understand auditory skills development in children, and are aware of the academic demands of the classroom. In some cases, EAs may, in fact, be responsible for direct service delivery relative to developing listening skills. More often, this professional (in schools and programs fortunate enough to have one) may provide some of the

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mentoring to SLPs and TODs alluded to earlier. As an example, the state of Colorado has a model program for CI mentors in regions across the state that is directed by an educational audiologist. In this program, teachers and SLPs in rural or remote areas of the state have access to an expert in cochlear implant habilitation that is geographically accessible to them. The reader is directed to [www.cde.state.co.us/cdesped/SD-Hearing.asp](http://www.cde.state.co.us/cdesped/SD-Hearing.asp) for more information on the Colorado Cochlear Implant Mentor Program.

### **AUDITORY VERBAL THERAPISTS**

There is a growing trend for school districts to engage the services of a certified Auditory Verbal Therapist (AVT) for children with cochlear implants. Based on the premise that concentrated focus on auditory development will yield the greatest gains, auditory verbal therapy is one approach to developing listening skills and spoken language skills in implant recipients. Although it is more likely that AVTs will provide private practice therapy outside the school setting, the movement to bring these professionals into the schools may assist in team building, which is often compromised when service delivery occurs outside the school setting.

### **CLASSROOM TEACHERS**

The classroom teacher in a general education setting is a vital member of a child's habilitative team. It is in this professional's care that large portions of the child's school day is spent. The general education teacher may have little, if any, information and/or direct experience with hearing loss and cochlear implants. However, this teacher brings a wealth of content knowledge and classroom management skills for the purpose of planning and implementing motivating lessons. To create an auditory learning environment in the classroom that allows a child with an implant to be successful there, the classroom teacher will likely need guidance with regard to encouraging the development of auditory skills. It may be that a teacher will enthusiastically embrace the notion of playing listening games that review content. The growing trend for listening and speaking to be addressed in statewide standards and the assessment

instruments that measure whether or not they have been met may make this recommendation more readily acceptable to the classroom teacher. If listening skill development is considered appropriate for all children, not just the child with a cochlear implant, the mainstream teacher may be more willing to allocate instructional time for this purpose. The novelty of a listening screen in the classroom for focused auditory play may be just the “hook” that keeps children engaged in this new instructional activity.

When classroom teachers’ awareness to the complexity of language that is found in classroom and content texts is heightened, they will be better able to monitor the child’s ability to follow and comprehend instruction. Keeping the TOD and SLP apprised of classroom themes or content units will allow these speech and hearing professionals to incorporate authentic classroom materials in their intervention. It is vitally important that the teacher monitor performance and share that information with the other members of the habilitative team so that supports may be added as deemed necessary.

In preparation for working with a child with a hearing loss in the mainstream, the classroom teacher will generally receive information about teaching this population. A number of resources exist for this purpose including Mangiari’s (1993) *A Child with a Hearing Loss in Your Classroom? Don’t Panic!* and Otto and Kozak’s (1998) *Questions Teachers Ask* (both available through AG Bell). However, we would like to include some global tips here for the instructional personnel in schools to consider.

### **SUGGESTIONS FOR ENHANCING A CHILD’S PARTICIPATION IN REGULAR EDUCATION SETTINGS**

- Establish a genuine and personal relationship with the child with an implant. Be sure to engage the child and go beyond the smile.
- Don’t be afraid of the child with a cochlear implant or his/her equipment. Determine what your role will be in management of the device.
- Understand and use additional classroom amplification systems.

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- Consider a buddy system for all children in the classroom so as not to single out the child with the implant. Each child in the class may have a buddy that can be a partner in the classroom or would be available for contact after school about homework or other school issues. Make sure the child with the cochlear implant is assigned a responsible buddy.
- Establish high, but realistic, expectations for the child with a cochlear implant. Make modifications to initial expectations as warranted by performance.
- Make sure that the directions that are given to the class are clear. Consider instituting a routine that calls for one child to restate directions to gauge their clarity.
- Use visual materials to support content whenever possible. Use of the board to support or enhance verbal instruction will benefit all children in the classroom, but especially the child with an implant.
- Be careful in the development of authentic assessment materials. Do not include complex language that obscures the evaluation of content knowledge.
- Develop and use a consistent verbal attention-getting phrase that is linguistically appropriate for the child's age. Share that with the TOD or SLP so they can work on a child's recognition of that attention-getting device.
- Be tolerant/aware of the communication habits of the parents of children who have previously been in special education placements. They are used to direct and easy access to all school personnel. Establish a protocol at the start of the school year that works for everyone involved.
- Establish routines and follow them consistently so that the child can become accustomed to recurring patterns in scheduling and procedures. Be sure to be explicit about changes made in daily activities.

When a child's successful participation in a general education classroom is supported by an additional service provider such as an

educational interpreter, a transliterator, or a note-taker, care must be taken to include these individuals in discussions regarding the implementation of the habilitative plan. Classroom instruction will proceed much more efficiently when parameters for roles and responsibilities of student support personnel have been clearly defined. Regular meetings of the entire habilitation team will ensure good communication and a cooperative effort put forth by all individuals involved.

## **SPECIAL INSTRUCTIONS FOR THE “SPECIALS”**

In addition to the classroom teacher, a number of instructional personnel will see the child on a regular basis. It is important for these teachers to be aware of the tips outlined above. Subject-matter-specific instructions are included here.

### **THE MUSIC/CHORUS TEACHER**

Many children with cochlear implants enjoy music education activities successfully and some become quite accomplished with instrumental or vocal music. The important role of melody in speech production of a child with a cochlear implant can be supported through music education that includes attention to vocal quality, vocal variation, and phrasing.

The music teacher who has a child with an implant in class will want to ensure that the device is functioning properly. If the child is old enough, it may be sufficient to just quickly verify that the child has good function with the device that day. Keep in mind that it may be difficult for the child to understand directions over the musical activity be it singing or band practice. It may be helpful to establish certain phrases that can be used consistently to communicate direction (e.g., “Strings, be ready for your entrance”). Vocal music may contain words and grammatical structures that are unfamiliar to the child. Enlist the support of the itinerant TOD or SLP in setting up clear guidelines for the child to ensure understanding of the logistics of the music class as well as practicing proper pronunciation for those in choral music.

## THE ART TEACHER

Be aware that a child in an art room will often need to split attention between the model of the product and the process of its creation. Directions that are presented while materials are being distributed may be difficult for the child with an implant to follow because of the competing activity. On the other hand, the largely creative aspect of art allows a child to participate on a par with his or her peers as the relative language load of the task is minimized. Furthermore, there is often greater opportunity for one-on-one teacher-student interaction in art class as the teacher circulates about the art room and the children are working on their projects. The art teacher should take advantage of these opportunities to engage the child in conversation about particular aspects of the child's work. Children with artistic tendencies should be confident in their exploration of the many aspects of art and celebrate their talents and accomplishments.

## THE PHYSICAL EDUCATION TEACHER

General physical education classes incorporate gross motor activities that are well within the capabilities of the implanted child. However, it is important to remember that the external device should be secured during these activities to prevent damage. This is easily accomplished through the use of a sweatband to hold down the behind-the-ear processor. For children using body processors, additional tethering equipment may be needed. Children with cochlear implants are able to participate in the varied aspects of the physical education curriculum; implanted children are no different from hearing children with regard to the use of protective gear.

Physical education classes and school sports often allow students with strengths in bodily/kinesthetic intelligence (Gardner, 1983) the opportunity to excel at something in a world in which verbal/linguistic intelligence has high value. Many successful experiences in general education for children with hearing loss have begun with prowess on the court or out in the field. Physical skill begets acceptance and, for the very skilled, even admiration despite the difference in hearing status. Even though students with cochlear

implants have greater opportunities to have successful engagements with their hearing peers in the classroom, status may be enhanced when students are athletically inclined. To nurture the positive outcomes associated with physical skill, the PE teacher will want to ensure that a child's physical accomplishments are matched by skillful play and knowledge of scoring procedures. This means that rules and plays need to be understood by the student using an implant. Complex and detailed instructions for playing team sports should be made explicit to the implant recipient. There is nothing more embarrassing for a player than making an error not from lack of skill but from lack of rule knowledge in the heat of competition.

Furthermore, the acoustic environment of most school gymnasiums presents particular challenges for a child using implant technology. The absolute size of the facility and the many hard surfaces found in gyms make it a highly reverberant listening environment. The background noise associated with physical activities, whether it be a bouncing ball or cheering crowd, will make it more difficult for a child with an implant to follow directions called out from the sidelines during play. For this reason, it may be helpful to develop some particular hand symbols or gestures to cue plays.

Among the additional instructional professionals with whom the child may have contact are the media specialist or librarian and the computer teacher (in those school programs that have remained committed to the concept of a "computer class"). It would be prudent to include these professionals in any discussion of accommodations for the child with the cochlear implant. Even though their absolute contact time may be limited, issues related to seating arrangements, precautions, communication tips, and general expectations may be addressed.

## **OTHER SCHOOL PERSONNEL**

It would be an oversight not to mention other members of the school community who are also a part of the child's life away from home. From our vantage point, two of the most influential individuals in schools have yet to be named: the school secretary and the building custodian. When these individuals know the student with an implant by name, two powerful allies for the child are added to

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his or her “corner.” Opportunities for the child with an implant to interact with these power brokers may serve to enhance a relationship that can provide support and assistance outside the instructional team.

Among the other adults with whom a child may come in contact on the way to school and in the lunchroom are the bus drivers and cafeteria workers. When these individuals with daily (and crucial) interaction with the child are “in the loop,” the greater is the likelihood that communication with the child with the implant will be successful.

### **SUMMARY**

Although it may “take a village” to *raise* a child, it “takes a school community” to *educate* one—especially a child with a cochlear implant. Community members who work cooperatively and not competitively and respect all the players, regardless of their roles, will be more likely to create an educational environment that will assist a child with an implant in reaching his or her fullest potential with the device. At the very least, all instructional and noninstructional school personnel, especially those in mainstream settings, should have basic knowledge about the cochlear implant device and be encouraged to establish a personal relationship with the child with an implant. Fundamental communication tips will be helpful to all who see the child during the course of the school and particular instructional strategies for those “special” teachers will ensure that everyone is an active player on the child’s habilitative team.

## *Chapter 11*

# **LISTENING IN NOISY CLASSROOMS**

## **Room Acoustics, FMs, and Other Assistive Devices**

The remarkable outcomes observed in children who utilize cochlear implants cannot be overemphasized. However, it is important to keep in mind that even though these children are capable of impressive perceptual performance, they do not hear normally. It is equally important to remember that the average classroom in the United States may be poorly structured acoustically, thus placing even the hearing child at a disadvantage. Successful classroom behavior encompasses myriad tasks that require students to listen, comprehend, write, and comment all within minutes or seconds. For a student to successfully take notes in a class, he or she must comprehend the message, simultaneously, or within a short period of time, look down from the teacher, and write it legibly so that it can be meaningful later. For children with cochlear implants, (especially those who only use unilateral cochlear implants), this ability to retrieve and record spoken lessons in the classroom becomes even more challenging if the room is not acoustically ideal. It is critical that children in classrooms, whether they are hearing or have

hearing loss, be provided with the clearest signal. Accomplishing this requires a number of considerations. First, there is the classroom itself and how acoustically friendly it may or may not be. Second, there is the teacher output with respect to intensity and clarity. Lastly, there is the recipient of the signal who must bring to the task a series of capabilities ranging from detection to comprehension of the spoken material. A greater understanding of how these aspects interact with each other can assist the school professional in ensuring the best possible outcome for the child who uses a cochlear implant in the classroom.

## CLASSROOM ACOUSTICS

For a classroom to be optimal for a child's listening ability, background noise should be at a low intensity and reverberation time minimal. Sources of background noise include heating or ventilation systems, activities within the classroom or neighboring classrooms, and environmental noise outside the classroom. Reverberation refers to the amount of time it takes for sound to decay. In large, hard-walled rooms there is an echo quality that indicates a slow sound-decay time. However, in most classrooms, reverberation issues that are not obvious to the average listener may create poor listening environments for the child with a cochlear implant or the hearing child with a learning or auditory-processing disorder. In addition to distorting the main signal in the room, long reverberation times can also exacerbate background noise.

Background noise is measured in units known as signal-to-noise ratios (SNR) that can vary from negative to positive. An SNR +5 indicates that the main speaker's output is 5 dB above the noise; an SNR 0 indicates speech and background noise at the same level; SNR -5 would mean that the speech is 5 dB below the noise. Perception, therefore, improves as SNR increases. It is easier for a child to listen to speech at an SNR +10 than it would be at an SNR -10. Typically the poorest SNR occurs when the teacher is at the back of the classroom behind the students or when he or she is speaking too close to the noise source (e.g., standing near a noisy air-conditioning unit). Generally, it is recommended that children with hearing loss have at least an SNR +15 (Seep et al., 2000). At this level speech perception increases substantially.

To overcome compromised signal-to-noise ratios, amplification of the speaker's voice to an appropriate level over the noise is necessary. This can be accomplished using a variety of technologies that are outlined in the sections to follow. Obviously, the better approach is to build classrooms that are initially constructed to reduce background noise. Recently, the American National Standards Institute (ANSI) recommended that new classrooms should be designed to have a background noise of no greater than 35 dBA (ANSI, 2002).

Assessing reverberation time (RT) is a bit more complicated but can be performed using a standard formula. This formula takes into account the size of the room, the areas of different surface materials, and the absorption levels of those materials at certain frequencies. Ultimately an RT of 0.4 to 0.6 seconds is desirable. Unfortunately, most classrooms have RTs greater than 1 second (Seep et al., 2000). Reverberant rooms are treated by either decreasing the size of the room or increasing the amount of absorption. For older classrooms with high ceilings, adding a "dropped ceiling" that uses sound absorption tiling effectively treats both issues simultaneously. This may not always be easily accomplished as windows and lighting may prevent its construction. When a "dropped ceiling" is not possible, adding absorbing materials such as fabrics, cork boards, and carpeting can offer some relief. Sound-absorption materials that are evenly distributed throughout the classroom are more effective than those that are concentrated in only one area. Often, adding sound-absorption materials will contribute to reduction in background noise. Well-placed carpeting or tennis balls on the bottom of chairs will substantially reduce the amount of noise that occurs in the classroom. It is important to remember that all sound should not be absorbed. In larger classrooms, the teacher's voice must be able to reach the back of the room before the sound-absorbing materials soak it up. For all these reasons, it is important that classrooms with children with cochlear implants be assessed for RT and noise to ensure the best signal delivery.

## **TECHNOLOGIC ACCOMMODATIONS**

As noted previously, the speech output of the teacher is another major component of providing a good listening environment for the student. Teachers in acoustically advantageous classrooms who

speak softly or with a heavy accent will be a challenge to even the hearing child. For the child with a cochlear implant, the ability to follow classroom content under these circumstances will be met with great frustration. Regardless of teacher speaking style, however, the child who uses a cochlear implant must have a signal that can be consistently detected by the implant microphone. Personal or sound-field FM systems have increased in popularity to meet this need.

### **SOUND-FIELD FM SYSTEMS**

Sound-field amplification systems are the more traditional ones that have been used in large lecture halls for many years. They consist of a microphone into which the presenter speaks and well-placed acoustic receivers in the room which deliver the signal to the listener. These can be hard-wired, as is the case in most auditoriums, or they can use FM transmission to make them more portable from one room to the next. Placing a sound-field system in a classroom addresses two important aspects of the speaker/listener paradigm. By using such a system, the teacher's voice is amplified approximately 8 to 10 dB. This creates a more advantageous signal-to-noise ratio for the child. In addition, sound-field systems provide a more uniform signal throughout the classroom so that children seated in the back of the room have the same input as those in the front of the room.

Sound-field systems vary from compact, portable, battery-powered, single-speaker units to more permanently placed, multiple loudspeakers that can be situated in different portions of the classroom. In some cases, these loudspeakers can be placed on stands, mounted in the ceiling, or affixed to the walls. There are a variety of manufacturers of these systems. The reader is directed to Appendix C for a listing of distributors and their Web site addresses.

In survey studies of teachers who used sound-field systems, 96% found them to be effective. In addition, many of these same teachers reported reduced stress and vocal strain after their use. Similarly, 93% of students who use sound-field systems reported positive attitudes (Crandell, 1998). Educationally, this technology can enhance academic instruction through its use in oral reading and oral presentations.

FM systems cannot be used without attention to proper management. Calibration and output of the FM is critical to its delivery of the appropriate signal level. Systems that are set too low will have little effect; those that are set too high may be uncomfortable for some children. When FMs are set too high for children who use cochlear implants, they will be rendered essentially ineffective as the implant will detect the high-level input and automatically reduce it before delivering it to the child. Systems that are set too low will have reduced sound levels as they reach the implant microphone.

In addition to the calibration of the sound-field FM, the placement of the speakers is equally important. Speakers that are situated in the upper corners of the room will be less effective than those on speaker stands at a reasonable level relative to the child's ears. It is also important not to block the loudspeakers with pictures or posters as this will substantially distort and decrease sound output. Smaller portable desktop systems are more efficient in delivering the signal to the child, as they are placed in closer proximity to the user. However, to prevent them from abuse from falling, it is best to have some method of securing them such as the use of Velcro. Because these smaller systems can utilize both rechargeable and alkaline batteries, it is important to have a member of the school team who is responsible for their management.

Finally, as with any system, it is important for the speaker to wear the microphone in a manner that will be the most effective. For this reason, microphones that utilize a headband or occipital band and place the microphone directly in front of the mouth are the recommended technology of choice. Lapel microphones attached to garments are often too far from the speaker's mouth and are subject to clothing noise and interference from jewelry.

Evaluating the utility of any technology is important in determining its effectiveness. For children with cochlear implants, teachers can utilize the Screening Instrument for Targeting Educational Risk (SIFTER). This questionnaire focuses on observations of the teacher of the child's classroom performance related to good listening skills. A self-assessment inventory is available with the Listening Inventory for Education (LIFE). This inventory uses pictures of common classroom situations that could provide a listening challenge to the student. The student then indicates how much difficulty he

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or she experiences in each environment. Both these evaluations can be performed in a pre/post mode to assess the effects of the introduction of sound-field amplification.

It is important to understand, however, that sound-field systems do have their limitations. In excessively reverberant rooms, the 8- to 10-dB advantage may not be enough to overcome the poor acoustic environment. In very small classrooms there may be problems with feedback and benefit may be limited. Additionally, depending on speaker placement and the placement of the child relative to the speaker, the enhancement may still not be enough to overcome background noise. For this reason, personal FM systems may be a better method of choice for the implanted child.

**PERSONAL FM SYSTEMS**

Personal FM systems offer a more favorable signal-to-noise ratio as the input is directed to the child's assistive device. In the case of the child with a cochlear implant, FM coupling has evolved substantially over the past several years. Previously, when children used body-worn speech processors and FM systems were also body-worn, the equipment was extremely cumbersome. In addition, because the two devices required a direct coupling, problems with cable interface were frequent. Interference between the two devices and among other systems in the class was also problematic. Thus, FM coupling was used in a much smaller percentage of children with cochlear implants. More recently as both cochlear implant speech processors and FM systems have decreased in size, some of these problems have subsided. However, it is important to note that they have not completely disappeared.

Although FM systems offer a greater advantage in noise than a sound-field system, FM systems have more working parts and their functionality cannot be as easily verified as a sound-field system. This makes it crucial for school professionals servicing children with cochlear implants to be knowledgeable about these personal devices to ensure proper functioning. An FM system that is not working properly may actually decrease signal input to the implant user, thereby making the recipient more susceptible to distortion and reducing benefit required in noisy situations.

In studies of children with cochlear implants in noise, researchers have found that performance can decrease by as much as 50% as the SNR goes from quiet to +5 dB. Fetterman and Domico (2002) studied 96 children with cochlear implants and found a consistent drop in performance as the sentences were delivered in quiet and at SNRs of +10 and +5 dB. Given that the average classroom functions well below this level, it is essential for children with implants to have additional sound input to ensure auditory access to school content. However, as noted previously, as these systems are not as easy to monitor as sound-field systems there are certain prerequisites for fitting personal FM systems to children with cochlear implants.

Children who utilize a cochlear implant and are being considered for an FM should have at least 3 to 6 months of cochlear implant experience prior to interfacing the FM system. Children should have adequate communication skills (either oral or sign) to be able to provide feedback about what they hear with the FM and cochlear implant. With some cochlear implant experience, the child should be able to demonstrate reliable, age-appropriate responses to auditory tasks to ensure that progress is being made. Finally, someone at school should be identified as the main monitor of the device so that troubleshooting and listening checks can occur on a regular basis.

The variety of FM-compatible systems is more numerous than in previous years. There are systems that can be readily connected to body-worn processors without the use of unwieldy equipment. Devices that piggyback onto the existing speech processor and can be held in place easily are state-of-the art (see Figures 11-1 and 11-2).

Teachers and speech and hearing professionals must be aware of the numerous configurations and the proper settings for the transmitter and the receiver. As these differ from one device to the next, the best approach is to contact the individual cochlear implant manufacturer along with the FM manufacturer to ensure proper control setting.

Behind-the-ear speech processors have made FM use cosmetically appealing with greater reliability. For these systems to work in tandem, they require proper adjustment. Programming adaptations for the implant are often necessary to ensure that the processor is

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**Figure 11-1.** FM and Nucleus Cochlear Implant System



**Figure 11-2.** FM and Clarion Cochlear Implant System

set to receive the FM signal. School professionals must be aware that they cannot simply order equipment and connect it to the implant as it will not function appropriately. Knowledge of system battery requirements and rate of drain is necessary as these will vary among the different models. Failure to monitor this aspect of

FM usage may result in poor performance due to battery discharge that goes undetected.

Some systems can be monitored using headset earphones that are provided by the individual manufacturer. Again, the school professional should be in contact with the cochlear implant facility and/or the individual manufacturer to learn these procedures. Basic management of the FM should be performed daily by individuals who have been designated to fulfill this important role. This can be accomplished by using informal or iterative checks, versus more formal assessments.

Informal checks of the cochlear implant and FM system are quick and easy and can be performed by using a portable speaker, the monitoring headsets that accompany the implant, or standard behavioral listening tests. A small portable speaker purchased from a local radio store can provide the output for the speech and hearing professional to monitor the FM system. By plugging the FM transmitter into the speaker and then speaking into the transmitter, the signal can be heard through the speaker to ensure that the FM is functioning appropriately. The monitor headphones that accompany some of the cochlear implant systems are quicker and easier in performing this function. All that is required is the manufacturer-supplied earphones plugged into the FM receiver as the school-based professional listens to the signal while speaking into the microphone. In addition, the cochlear implant recipient can be asked to respond to variety of auditory-only stimuli.

Formal assessment of FM function can be performed using behavioral sound-field testing and/or electroacoustic measures. These tend to be more time-consuming and often must be completed on site. For behavioral assessment, the child's performance should first be determined in the cochlear implant-only mode and then with the cochlear implant and FM activated. When in the cochlear implant-only modality, the child's speech perception abilities should be measured in quiet and at a +5 dB SNR. Once completed, the FM system should be attached and the procedure repeated. Needless to say, this is a very time-consuming process and also presumes a certain level of performance from the child.

Electroacoustic assessment requires special equipment that is often available through the school system by the educational audiologist. This demands a certain level of skill and experience but does not necessitate any participation on the part of the child.

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A standard hearing aid test box is required so that the monitor earphones can be connected to the coupler. (If a cochlear implant system does not have monitor earphones this cannot be done.) Various recordings are made and compared to ensure proper function. For educational audiologists interested in further information about this method of assessment they are directed to Thibodeau (2003).

In comparing the different methods of verifying proper FM and cochlear implant function, it is clear that the informal listening checks, which utilize the monitor earphones, are the quickest and most efficient. No feedback from the child is called for thereby making informal listening checks a technique that can be used by the entire school team. Behavioral listening checks that are basic and request minimal detection and discrimination are also easy and efficient to use. The more advanced behavioral testing under traditional soundproof conditions using stimuli in quiet and in noise can provide a wealth of information, but are time-consuming and necessitate a particular level of performance by the child. Finally, the electroacoustic check does not entail any feedback from the child but requires experience and additional equipment on the part of the educational audiologist.

**SOUND FIELD VERSUS PERSONAL FM**

The choice of which audio enhancement system is recommended depends on a number of very important criteria. As noted previously, children should have some experience with their implants alone before fitting any of these systems. For very young children in preschool settings or children who have multiple disabilities, sound-field systems will ensure the signal advantage without the question of FM and implant function. For older children who have limited experience with cochlear implants, sound-field systems should be used until there is a comfort level on the part of the implant facility and therapeutic professionals regarding the child's level of functioning. The opposite is often true for adolescent cochlear implant users who find the presence of a totable system on their desk to be too much of a stigma. What is important is that no child should be fitted with an FM system until there is agreement among all professionals working with the child that the implant recipient is capable of giving feedback to them regarding its sound clarity.

## OTHER FM ISSUES

In addition to the FM being coupled to the cochlear implant, many children will also use a hearing aid or another cochlear implant on the opposite ear. Children can use FM systems coupled to the hearing aid or other implant successfully. These systems can be matched for frequency so that a single transmitter can be used by the teacher. Issues of implant recipient feedback remain the same.

## ADDITIONAL AUDIO DEVICES

As we live in an age of cell phones, computers, iPods, and CD players, the bombardment of sound from each of these is often overwhelming to those of us with hearing. Interestingly, children with implants also appreciate these latest technologic gadgets and gravitate toward them in a similar manner. Cell phone use in the United States is at an all-time high with the age of getting one's first cell phone decreasing each year. There are now children's cell phones that can be preprogrammed with only a handful of telephone numbers so that the child can call home, school, or a relative with the push of only one button. A large percentage of cochlear implant recipients enjoy telephone conversational skills and they are able to easily access this technology without any additional equipment. Some manufacturers produce telephone adapter connectors to enhance the signal for users who require it. Most use the telephone in a manner similar to hearing individuals.

Computer usage among the deaf has risen extensively as it has opened up communication in a manner never thought possible. E-mail access and instant messaging have contributed to an ease of communication that the deaf have not previously known. In addition, Web sites and software that generate speech signals for listening practice make the home computer an extension of the therapy room. These can be accessed using traditional speakers that are connected to the computer or through more direct input from the computer to the implant. It is crucial that implant recipients who connect directly to any technology that is interfaced with standard AC current use a surge protector to guard against any random power spikes.

Portable, personal audio systems are in widespread use in both the hearing and implanted population. Each implant manufacturer

offers a variety of interface cables that can often enhance listening through these devices. Experience suggests that it is an individual appreciation that drives the decision to use these special connectors. As music has become more accessible, many implant recipients (especially adolescents) are finding it enjoyable.

Music appreciation via a cochlear implant has only recently received some attention as initial studies of implant efficacy were focused on speech perception abilities. Presently, the majority of the research in this area has been performed in adult listeners, and, more specifically, postlinguistically deafened adult recipients (Gfeller et al., 2005). The implications for children who are raised using cochlear implants from a young age are unknown at the present time and warrant attention as these children progress through the educational system and are exposed to music.

Studies in adult implant recipients include anecdotal reports of music appreciation; however, group data demonstrate problems in pitch perception and subsequent poor perception of melody and harmony. As a group, studies show considerable variability among implant recipients on recognition of familiar melodies (Gfeller, Turner, et al., 2002) with no superiority of device or processing strategy. Interestingly, implant recipients have demonstrated significant improvement in timbre perception of instruments as a result of structured training after implantation (Fujita & Ito, 1999). Likewise, the implications of this for children are not yet known.

Additionally, it has been shown that the age of the adult cochlear implant user at the time of the testing is strongly related to music perception and enjoyment (Gfeller et al., 1998). Cognitive ability has also been shown to be predictive for some aspects of music perception. Some implant recipients report that music generally sounds like noise whereas others report some music as being acceptable and other music too complex. In recent studies that investigated "real world" music (Gfeller et al., 2005), cochlear implant recipients were compared to normal hearing listeners across three types of music: classical, pop, and country. The results indicated that the implant recipients rated music as less pleasant and more complex when compared to normal hearers. When listening to previously known musical pieces, the implant recipients were less accurate than their hearing counterparts. A weak correlation was found for age at time of testing and music appreciation with the younger listeners performing better. Additionally, performance on

speech perception measures and the amount of focused music listening time after implantation was also correlated with musical enjoyment. Clearly these data suggest that earlier exposure to music may reflect better music identification and appreciation. It would also suggest that trained musical appreciation will foster this ability. As young children often use music as a learning tool it is important to continue to explore this ability in children with cochlear implants.

## SUMMARY

The cochlear implant can provide its recipients with a wealth of information with respect to spoken language. To maximize benefit in a classroom setting, the use of an FM system is strongly recommended. These systems can take the form of sound-field devices from which the entire class can benefit or personal systems used by the individual. Decisions about which systems are most appropriate are based on criteria that depend on the child's experience with the cochlear implant and his or her ability to express verbally any problems that might arise.

It is essential that teachers receive in-service training on the use of FM systems to ensure proper use. The role of the educational audiologist is critical in the follow-up and maintenance of these devices. The school team is challenged to ensure the child's compliance in utilizing the FM appropriately to contribute to success. As FM systems become smaller and more accessible their use will continue to grow.

In addition to FM systems, there are a variety of accessories to enhance delivery of other signals to the cochlear implant recipient. These include interface cables that connect the recipient with cell phone, computer, or musical delivery devices. As musical delivery systems become more widespread, exposure to this type of stimuli is increasing among implant users. The level of appreciation for music is often individual but still falls short of that of the hearing person. As research continues in this area, information about children's perception of music will become available. The ramifications of training children with cochlear implants at young ages in the realm of musical perception are uncharted territory that needs further investigation.