Considerations Underlying the Selection and Utilization of Classroom Amplification Systems

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INTRODUCTION

Hearing impaired children are being educated in a variety of classroom settings, ranging from the self-contained classroom in a special school to a fully integrated regular school, and with a diversity of educational approaches, from highly structured group instruction to completely individualized "open" type classrooms. The proper selection and utilization of classroom amplification systems, under all the different possible permutations of educational circumstances, is one of the weakest links in our efforts to educate hearing-impaired youngsters. All "methods" of instructing these children espouse maximal exploitation of residual hearing; the translation of this avowal into a sophisticated awareness of confounding problems, however, is quite something else. No "method," and few educational programs, can demonstrate in concrete terms that they have selected and are utilizing classroom amplification systems with optimal efficiency. This paper will be devoted to a discussion of some of the factors underlying their appropriate selection and utilization in specific classroom and instructional environments.

GENERAL PRINCIPLES

In this section, the general principles underlying the utilization of amplification systems in any educational environment will be discussed. None of the factors are particularly esoteric or unattainable, nor considering the implications, should they be considered unrealistic.

First, the amplification must permit, and be utilized in such a fashion, so as to provide the child with the best possible signal-to-noise ratio at all times. Unless the signal can be clearly differentiated from the noise, and for maximum intelligibility the hearing impaired listener requires a higher signal-to-noise ratio than normal hearing individuals (Gengel, 1971), the best auditory reception will not occur. A poor signal to noise ratio can easily "turn the child off" amplified sound and preclude effective utilization of the auditory channel.

Second, the child's own utterances must be clearly audible to him. Without auditory monitoring of his vocal output, the chances are remote that a child will develop esthetically acceptable and intelligible speech. Even if a hearing loss permits just low frequency, perhaps vibrotactile monitoring, the prosodic components of the speech signal are still available for exploitation (Ross, et al, 1972).

Third, the amplification system must permit child-to-child communication in a natural and routine fashion. If a child does not derive substantial benefit from audition in communicating with his peers, then it is not likely that his residual hearing will play an important role in his developing communicative mode.

Fourth, provisions for amplified sound must be made as soon as reasonable certainty exists that the child does indeed exhibit a peripheral hearing loss. The possibility of co-existing neuropathologies does not obviate the necessity for remediating the hearing impairment (Kleffner, 1973). The home is also an educational environment, perhaps the most important one, and the same care and analysis must be made in this situation as is made for classroom settings.

Fifth, binaural amplification should be the rule when hearing aids provide the amplified sound, with monaural fittings the exceptions in particular cases. The evidence (Ross, et al, 1974) and our own experiences have convinced us that binaural amplification is superior to monaural for most children.

Sixth, the fewer conversions a signal must undergo, the better. Systems which use both Radio Frequency (RF) and Induction Loop Amplification (ILA) transmission increase the probability of a breakdown in one or the other system; in addition, the evaluation of the electro-acoustic changes occurring in the signal becomes more difficult with such an arrangement.

Seventh, the noise level in classrooms must be reduced, either at the source or through appropriate sound treatment (Ross, 1971). The hearing impaired individual manifests a greater relative decrement upon speech intelligibility in the presence of noise than do normal hearing persons; this is particularly true when speech is processed through a hearing aid. Educators should know that the acoustical evnironment confronting the hearing impaired cannot be appreciated with normal ears (Tillman, et al, 1970).

Eighth, supplementing (not substituting) audition with vision will result in increased speech comprehension. Some increase will usually occur regardless of the severity of the loss (Fisher, 1964; Erber, 1972).

Ninth, from the teacher's point of view, the system must be simple to operate and maintain. The designers and salesmen of equipment frequently underestimate the complexity of a system because of their own great familiarity with it. The same design care must be exercised in such apparently superficial concerns as straps, control availability, rechargers and cord durability, as in the electro-acoustics and esthetics of the device.

Tenth, classroom amplification systems require the same acoustic flexibility currently built into a good hearing aid. The child is not receiving the optimum auditory signal if it is not possible to individually adjust the electroacoustics of his own unit to conform to the severity and configuration of the hearing loss in his two ears. Since the child can receive signals from both the teacher and environmental microphones, the unit requires separate on-off, and possibly gain controls for each input.

Finally, it is not likely that we will realize the potential benefits of amplified sound if the administration and staff in an educational setting do not have an informed commitment to its exploitation, and if the appropriate staff and equipment are not included as an integral part of the educational program. This is a key point, without which all our good intentions are likely to come to naught. This point will be covered more fully in a later section.

SELF CONTAINED CLASSROOM IN A SPECIAL SCHOOL

Superficially, recommendations for this type of classroom are the easiest to make. Provisions must be made for the teacher to broadcast to the entire class, and for the children to hear their own voices and each other. Its superficiality is misleading, however. If structured, group instruction is the dominant theme in the classroom, if the teacher feels no great need for much mobility, and if the children are usually seated at their desks, then a hard-wire system is probably adequate. The problem is, however, that it is usually more difficult to provide the necessary provisions for auditory self-monitoring and child-to-child communication with such a system. If there is one microphone and it is around the teacher's neck, then the children can hear the teacher well, but not themselves or each other. If the microphone is located equidistant from the teacher and the children, an optimal signal will not be received in any condition (Hirsh, 1968). If each child is provided with his own desk microphone, then theoretically they should be able to hear themselves, each other, and the teacher very well. With eight or nine open microphones, however, each child will receive the amplified input from each one of them. Such sounds as tapping the desks, scratching paper, shuffling feet, moving books, and attempted private communication among the children are all amplified and delivered to every child. The teacher's voice in this situation is likely to be buried beneath all the other sounds. Effective use of a hard-wire system with a number ot open microphones requires a very disciplined class and teacher. Damashok and Boothroyd (1973) have constructed a unit in which a very thin boom microphone is hooked around the top of the ear and suspended several inches from the child's mouth. They report increased child-to-child intelligibility scores and increased responsivity from the children to their own voices. Similar units are commercially available (Paseman, 1971). Some problems with extraneous sound pick-up, particularly inadvertent children's vocalizations, still remain however. Perhaps the ultimate in such a unit would be a directional voice-actuated microphone with a fairly high activating threshold in front of each child. In the meantime, many teachers function quite well with the hard-wire system by hand holding the microphone and moving it in front of the mouth of whoever is speaking.

Loop systems, wired or wireless, always include provision for teacher transmission, self-monitoring, and child-to-child communication. The ILA systems, which have been used the longest, also seem to have the most problems (Ross, 1969). Variations in the signal strength in the room, spill over into other rooms, and undesirable

electroacoustic changes are common. If each child wears a body hearing aid, if there is a microphone/telephone switch with a properly oriented telephone coil in the aid, and if spill-over and signal strength in the room can be controlled, then this system can serve quite well. In my experience, there seem to be too many "ifs" for assurance that a good signal can be delivered to the child. In some programs with ILA systems, I have observed children with ear level hearing aids. These aids could be either switched to microphone or telephone, but not to both simultaneously. In one case, the child, if the telephone loop was orientated correctly (which is doubtful), could hear the teacher but not the other children or himself. In the other case, they could hear themselves and the other children very well, but not the teacher.

The RF systems are able to obviate most of the problems found in an ILA system. With RF transmission, it is not difficult to ensure relatively equal signal strength throughout the classroom. Spill-over can be contained by providing sufficient carrier wave frequencies. Each receiver unit in a RF system, whether wired or wireless, incorporates either one or two environmental microphones which enable the unit to be used as a body-worn hearing aid. The RF system permits the child and teacher to move throughout the classroom without affecting the quality of the received signals. Such apparently mundane events as snaps that keep breaking, and batteries that do not hold a charge for the entire school day are common and interfere with our purpose, but they do not negate the advantageous concept of an RF auditory training system. The major conceptual problem occurs when the teacher, for a number of educational reasons, is not broadcasting to the class as a whole. Every child in the classroom, no matter where they are, who they are talking to, and what they are doing, will receive the teacher's transmission loud and clear. It is a very frequent occurrence to see a teacher working with a small group of children, while another teacher or an aide is tutoring one or two children off in the corner of the same room. In this situation the children are hearing the teacher through the RF transmission and the aide through the environmental microphone(s). The competing signals received in these instances are hardly conducive to good auditory reception and development. The rule here is that when a teacher is not broadcasting to the entire group, her transmission must be de-activiated either at her microphone or at the children's receiver pack. The monitoring microphone(s) on the pack will then permit it to be used as either a monaural or binaural body hearing aid (preferably binaural). Otherwise the children are exposed to an inconsistent cacophony which has little relevancy to their ongoing activity.

Currently, children with ear-level hearing aids are misfits in this type of classroom unless group instruction is the predominant educational approach. In order to utilize the group auditory trainer, of whatever type, they must first relinquish their ear-level aids. During group instruction, they should receive a superior signal with the group system; during an individualized instruction period, the signal they receive with the auditory trainer used as a body hearing aid is probably

inferior to that they obtain with properly fitted ear-level binaural instruments. The time ratio of group vs. individualized instruction, the inconvenience and time it takes to change systems, the relative effect of room acoustics upon the speech signals received with the ear-level aids and the auditory trainer used as a body hearing aid, the curricular significance of the material at different times, are but a few of the considerations the educational audiologist must weigh in evaluating the appropriate amplification in this particular situation. In making the decision in this and other cases, the deciding principle is to ensure that the child receives the best possible auditory signal for his most important academic and social experiences for most of the time.

SELF CONTAINED CLASSROOM IN A NORMAL PUBLIC SCHOOL

The considerations are similar to those obtained in self-contained classes in schools for the deaf, with a few significant differences. Overspill of the signal from one room to another is no problem. More of the children will probably be using ear-level aids then would be found in schools for the deaf. If the class functions as a group for most of the day, then the group auditory training unit can be substituted for the child's aid(s) for the entire day. If there is a great deal of individual instruction, and some non-academic social integration with the hearing children, then the relative effectiveness of the auditory trainer used as a hearing aid and the child's own aids, have to be weighed. An important consideration here is the fact that more care is usually devoted to adjusting the electroacoustics of the child's personal hearing aids to his residual hearing than is the case with auditory training units. For example, an aid may be adjusted to emphasize the low frequencies in a child with just low frequency hearing, while the auditory trainer may either not permit such adjustment or the teacher may not be aware of its necessity. In this case, the child would not be receiving an optimal auditory signal for the period of time the auditory trainer is being used as a hearing aid. In any special classroom in a public school, it is very necessary to provide the hearing impaired children with the best amplification for the period of time they are socially interacting with normal hearing children. The conversations which occur at these times should be considered among the most important speech and language experiences the children will have. It behooves teachers to take the time and trouble to change from auditory trainer to hearing aid, and back again, to give the hearing impaired children the most fruitful exposure to this important material.

RESOURCE ROOM IN THE PUBLIC SCHOOLS

Looping a room is less appropriate in this type of situation. The children are in the resource room for individual or small group instruction; the rest of the time they are and should be in the regular classes. Wireless systems are the most appropriate auditory training units in this educational enviroment; provision has to be made, how-

ever, for a number of microphone/transmitters on different broadcast frequencies. The unit must permit individual or small group instruction in the resource room while not transmitting to other children in the same resource or in other rooms in the school. The children attending regular classes carry the appropriate microphone/transmitter to their teachers and return with it to the resource room. The unit must permit easy modification of the FM carrier frequency signal to that used for group instruction in the resource room, and then back to another individual frequency when required.

Under these conditions, it is necessary to have enough microphone/transmitters with different carrier frequencies to cover the possible full integration of all the children at any one time. Some of the children may be attending the same integrated class, and this will reduce the number of transmitters required. In some of the intergrated classes it may be inappropriate to utilize a wireless FM auditory trainer system and this will further reduce the number of required microphones (it is assumed that a separate receiver pack, properly adjusted electroacoustically, is required for each child). Possible examples of such classes are art, laboratory sciences, physical education, and library. As stated earlier, at this time the educational audiologist must weigh the relative advantages and disadvantages of the child changing back to his hearing aid for these classes, rather than continuing the use of auditory trainer as a personal body worn hearing aid.

THE FULLY INTEGRATED HEARING IMPAIRED CHILD

Again, the educational enviroment has to be carefully evaluated. The kind of auditory training system utilized in a conventional, highly structured type classroom emphasizing group instruction will not be the same used in an "open" classroom. In the former, the use of a wireless system by the teacher can provide the child with an excellent signal from the teacher and permit the hearing-impaired child to profit maximally from the group instruction (Ross and Giolas, 1973). In the "open" classroom, the occasions for group instruction may be few and far between. They must be evaluated first, in terms of the time involved in changing and then re-changing systems and second, whether it is possible to receive an acceptable signal in the group situation with the hearing aids (perhaps helped by the judicious use of absorbent material in the classroom and by the child placing himself closer to the teacher). At the present state of the art, auditory training units have minimal value in any instructional system which emphasizes a truly individual approach. In these circumstances, the teacher rarely broadcasts to the class as a whole. Unless we want the hearing-impaired child to hear everything the teacher says to all of the children which is not very desirable, particularly when child-to-child communication is occurring, then no broadcast system is appropriate.

The "open" classroom, particularly if it is noisy, seems to lend itself to the utilization of powerful, ear-level, binaural hearing aids

with directional microphones. Some companies are now making moderately powered ear-level aids with directional microphones and in the near future we should be able to anticipate furtner developments along this line.

SUPPORTIVE AUDIOLOGY SERVICES

In my judgment, no educational program is likely to make the best use of a child's residual hearing unless provisions are made for intensive and continuing audiological services. We now invest a great deal of money for auditory equipment, and give lip service acknowledgment regarding the need to exploit residual hearing; however, these declarations of intent are not being converted to reality. When large educational programs with perhaps 200 to 600 hearing impaired pupils enrolled can boast but one audiologist, one ancient pure-tone audiometer, and one converted closet as a test room as the sum total of their audiological services, then it is apparent that there is no real intention to utilize residual hearing and that the whole situation is a bit of a charade.

I am not ascribing malicious intent on the part of the educators who function in programs with less than adequate audiological services. For them to make a real commitment, organizationally and financially, to the full utilization of residual hearing, there has to be informed understanding of the inherent possibilities. The most effective way to gain this understanding is to observe, personally or vicariously through the literature, the benefits reaped by the children when such a long-term program is instituted. The problem is circular, however; the hoped for progress will not occur unless appropriate audiological services are provided, but these services will not be provided unless educators are convinced of their efficacy. Such examples as could be given by a few programs in this country are, unfortunately, rarely documented in a convincing fashion.

It is necessary, however, that the implementation of effective, supportive audiology services not wait until sufficient evidence has been accured for an unequivocal demonstration of its efficacy. First, the confounding variables human beings present in any type of behavioral research almost always result in less than clear-cut findings. Only the "believers" are easily convinced; the rest can always find some uncontrolled variable which may have vitiated the results. Second, since we are dealing with human beings in their optimum learning periods, any delay means that some children will be denied any chance of achieving their auditory potential. And third, while we do not have the kind of evidence we should have (and in my judgment, that we should have had long since), there is nonetheless sufficient information available currently to merit the institution of appropriate audiological services. The problem is that too many educators of the hearing impaired are not conversant with this information, and worse, do not have the background to enable them to objectively evaluate it.

There is information available now, for example, to support the contention that efficiency of speech production (Montgomery, 1967; Boothroyd, 1972), speech discrimination (Ross et al, 1972; Neuss, 1972), and academic achievement (Quigley and Thomas, 1968) are all related to the degree of residual hearing. This is hardly surprising; it should not even be necessary to make the contention that the degree of speech and language handicap a child presents is a function of the degree of hearing loss they manifest. The fact that it is, and the clear implication that we can reduce this handicap with effective amplification practices, testifies to profession's inadequate understanding and utilization of a child's residual hearing.

An educational program which limits its audiological intervention to a yearly pure-tone test does not have appropriate audiological supportive services. These services should not only encompass valid puretone testing, but also include such responsibilities as routine and specially devised speech tests (phoneme perceptions, band-pass and filtered peech tests, monaural and binaural intelligibility measurements, comfortable and uncomfortable loudness level assessments, articulation-gain functions, etc). behavioral and electroacoustic hearing aid and auditory trainer evaluations, taking ear impressions and recommending earmold type, analysis of classroom acoustics, conducting in-service training programs, participating in admissions committee, devising and administering auditory training tasks and conducting a children's outpatient audiology clinic. Community speech and hearing clinics cannot adequately meet these kinds of responsibilities. They see the children on an intermittent basis, their communication with educational programs are either superficial, unrealistic, or absent, and their authority in the classroom is nil. For the audiologist to be an educational resource, he must be administratively, and physically as well, an integral component of the educational program.

CONCLUSIONS

I have attempted in this paper to present a general overview of the factors underlying the proper selection and utilization of classroom amplification systems. This is not a trivial goal. We are playing for high stakes; the reduction of the profound handicap imposed by a hearing loss. It is unrealistic to expect overburdened administrators and teachers to add these duties as yet other of their many responsibilities. Nor should they. In general education, we welcome such resource personnel as psychologists, guidance counsolors, remedial reading teachers, learning disability teachers, media specialists, and speech and hearing therapists. In the education of the hearing impaired, on the other hand, the one resource person best equipped to understand and deal with the heterogeniety of hearing problems these children present, is either absent or in short supply. It is an inconceivable situation, made possible only by inertia and ignorance. We will not, in brief, realize the speech, language, and educational potential inherent in the effective employment of amplified sound without the contribution of a fully equipped and staffed supportive audiology service.

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