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Journal of Ear, Nose and Throat Disorders

Review Article

Enhancing Communication through Environmental Design for Adults Who Possess a Decline in Peripheral and Central Auditory Function

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Submitted: 24 December 2018

Accepted: 16 January 2019

Published: 18 January 2019

ISSN: 2475-9473

Keywords
- Hearing impairment
- Hearing rehabilitation services

Abstract

Introduction: The role of audiologists and other health services professionals in environmental design on behalf of older adults with aging auditory and visual systems is presented along with specific techniques for design modifications that can be readily applied to reduce barriers that can restrict older adults with impaired hearing from participating communicatively in their frequented listening environments. These services bring older patients, audiologists and ear, nose and throat physicians into a close working relationship, providing tangible results to improve the ability of older adults with impaired peripheral and central auditory function to hear with greater efficiency in otherwise difficult listening environments, and therefore participate in their activities of social, business and daily living with less difficulty.

The problem: The role of the audiologist and other health care professionals in the provision of hearing rehabilitation services on behalf of adults with impaired hearing is expanding as our knowledge of hearing as a factor in aging likewise expands. The complexities involved in the peripheral and central auditory components of presbycusis along with the compounding affects of the visual and auditory environments can negatively influence an adult's ability to function communicatively in their frequented listening environments.

In the past, audiologists and other health care professionals generally found that they could not do as much as they desired to assist their adult patients in acoustic or visual design modifications to alleviate or prevent environmental interference in communication. This, in part, was probably a result of a lack of academic preparation in the area of environmental design. Training in that area has in most instances not been readily available to students of audiology, or in any health services profession, as it still is not generally available in the majority of preparatory programs. What has too frequently done in the past is to recommend design changes in communicative environments of older adults with impaired hearing either through some very basic knowledge in the area, logic, or "by the seat of their pants" so to speak without being fully aware of why the environmental design changes work.

Rather than a "seat of one's pants" approach to environmental design on behalf of older adults with impaired hearing, this article will introduce those who serve older patients with impaired hearing to concepts and principles of environmental design that take into account the peripheral and central auditory aspects of hearing impairment in older age. Therefore, the purpose of this article is to present relevant information on environmental design for audiologists and others who serve the unique needs of older adults who possess impaired hearing, including design concepts, and the physiological bases for those design considerations so they will become more conversant in this area of service.

INTRODUCTION

The Need for Design Modifications for Older Hearing Impaired Adults

Many public and private listening environments play havoc with the aging peripheral and central auditory systems. As adults age, those who at an earlier age may have noted only some difficulty in specific degraded listening environments, may now be experiencing frustrating difficulty. Both acoustic and visual environmental factors may be interacting to cause the aging adult to have difficulty in speech understanding, although the reasons may not be evident to the listener. Older adults may blame the difficulties on the speaker, when in fact it may be the reverberant characteristics of the meeting room, or the anechoic environment of their home, or the combined effects of both auditory and visual distractions of a social environment or the multipurpose room of a health care facility, or other possible environments in which they find themselves. The result may be the avoidance of places where older adults would otherwise like to be, and thus greater isolation than is necessary.

In order for constructive services in environmental design to be provided on behalf of one's patients, audiologists and others who serve older adults with impaired auditory function should become more than conversant in this important area. Services in environmental design are very tangible, and in many instances show immediate benefit on behalf of one's patients.

Auditory Changes in Aging that Interact with Environmental Influences

Changes in both the peripheral and central auditory systems can occur in conjunction with advancing age:

The Peripheral Auditory System

A decline in the peripheral auditory system's functioning generally occurs with a fair degree of regularity over-time. One's lifestyle, noise exposure, heredity, diet, state of cardiovascular health, and others result in some degree of negative change within the cochlea with an accompanying sensorineural hearing loss in at least the majority of adults as they age—from younger to older. A classic description found in Hawkins (1973) presents a concise written summary of the insidiousness of those changes, as follows:

Unlike Dr. Oliver Wendell Holmes' New England Deacon who built the wonderful one-horse shay, the architect of the cochlea did not design it to give perfect service for "a hundred years to a day", or even the traditional three-score-and-ten. Its condition in old age, however, seldom represents the effects of aging alone, but rather the accumulative, combined assaults of noise and drugs, as well as time (p. 139).

The result is essentially a gradually progressive sensorineural hearing loss that primarily involves the higher frequencies. Since approximately 2/3 of the phonemes of American English possess important high frequency acoustic components that allow a listener to distinguish one phoneme from others, a hearing loss that primarily involves a decline in hearing for the higher frequencies is, of course, going to have a negative effect on speech understanding (Hull, 1973). An adult with a high frequency hearing loss who finds her or himself in a noisy or otherwise acoustically distracting environment that either masks the lower frequencies of speech, or otherwise distorts the complex phonemes of speech is placed in double jeopardy in regard to speech understanding. And, those environments are faced by adults with hearing impairment with a fair degree of regularity.

The Central Auditory System

The CNS auditory system also changes with age among the majority of adults. The central auditory system's ability to process the complex acoustic/phonemic elements of speech with the speed and precision necessary for precise speech understanding appears to decline slowly throughout one's adult life. This involves both the complex brainstem auditory pathways and the primary and association areas of the brain.

If the slightest decline in the speed and precision at the level of the brain stem and/or auditory cortex that is needed to process the acoustic/linguistic components of speech is noted, and if that decline in speed of processing is coupled with a peripheral hearing loss for the higher frequency phonemes of speech, then the difficulties that older adults may experience in hearing and understanding speech will be compounded. Further, if those difficulties that appear in older adulthood are further multiplied by attempting to communicate in listening environments that are not acoustically designed to support hearing and speech understanding, then the difficulties experienced by older listeners become even more dramatic.

Problem Environments

Meeting Rooms, Church Sanctuaries, and Other Frequented Environments: Meeting rooms, classrooms, church sanctuaries, church fellowship halls, nursing home all-purpose rooms, auditoriums, bank lobbies, and many other environments in which adults of all ages are required to listen and communicate are generally not conducive to hearing and understanding speech. They either resemble reverberation chambers (too many almost subliminal echoes), or on the other hand, anechoic environments (environments in which sound has difficulty traveling to the listener because they are absorbed or blocked, such as a typical home environment).

Numerous meeting rooms, classrooms, restaurants, church sanctuaries, church fellowship halls, nursing home activity rooms, and many places of business such as banks are constructed on the same reverberant principle. They are either square or rectangular in shape, with hard floors (tile, concrete, marble, or wood), sheetrock , concrete block, or brick walls, "acoustic" tile ceilings which are sound reflective, white boards or black boards in classrooms and some meeting rooms, uncovered windows, glass covered pictures, or possess other sound reflective surfaces. Further, most church sanctuaries have hard wooden pews, vaulted ceilings, stained glass windows, hard reflective walls, hard floors (except for perhaps a strip of carpeting down the center aisle), all of which are sound reflective/reverberant surfaces.

Homes

Typical home environments interact with sound in a manner that is the opposite of that found in the reverberant environments of churches and typical meeting rooms. Homes are designed for comfort, and are generally furnished in such a way that there are few, if any, reverberant characteristics. They become essentially *anechoic* chambers. That is, they do not give sound the "life" that is needed to travel well. There are few, if any, reverberant characteristics that enhance sound transmission.

One may surmise, then, that if too much reverberation, or too many echoes, in a listening environment are bad for speech understanding, then a typical non-reverberant home environment should enhance hearing. That is not the case. Many homes designed with the principle of comfort in mind restrict the movement of sound by absorbing it before it can travel, thereby deadening it. Soft carpeting, window drapes, soft chairs and sofas, wall paper, and heavily textured ceilings all absorb sound, so a complex acoustic signal such as speech cannot travel far enough to be heard well from any distance. Further, since speech comprises an extremely complex set of acoustic signals, it cannot negotiate stair wells (up or down), travel through doorways, or move around corners and be received by the listener well enough to be understood. Music is a less complex signal, and so will carried with at least a fair degree of accuracy in a home environment—perhaps not the words to the song, but the melody will travel fairly well.

Considerations for Environmental Design Modifications

It is not necessary to engage in extensive renovations when

working to improve environments to enhance them for purposes of hearing and listening efficiency in communication. Even modest changes in the listening environment can make a positive difference. Some of the environmental modifications can be made by the service provider. For others, the person who possesses the auditory/communicative difficulties will necessarily be her or his own advocate and become sufficiently assertive to suggest changes that will improve the listening/communicative environment. The service provider (audiologist or other) can also be the coach on behalf of the adult patient and her or his significant others to assist in making simple environmental changes.

Meeting Rooms, Church Sanctuaries and Other Typical Listening Environments

The task is to reduce the reverberation/echoes to enhance the transmission and quality of distortion free speech so that it is more easily heard and understood. The frustrating aspect of a reverberative listening environment is that the room may actually carry the speech signal so well that the individual may experience little difficulty "hearing". At least it seems to the listener that she or he is hearing fairly well, or at least loudly enough, in that environment. The difficulty experienced by the listener in understanding what is being said is caused by that same room reverberation, or the almost subliminal echoes that are the result of the physical characteristics of the room. The reverberation results in distortions of the speech signal, and therefore frustrating difficulties not in hearing, but in understanding what is being said.

Suggestions for Changes in Environmental Design

Here are some suggestions to consider. It is not intended that all of these are necessary to be added to change a listening environment. Choose one or two, and they should suffice if they are found to be the most appropriate for those who need them:

1. Since most rooms in which meetings or classes are held are usually square or rectangular in their design, and thus are naturally reverberant, do whatever is necessary to do away with the square or rectangular configuration. This can be done by adding light ceiling-to-floor drapes that are hung by an expandable curtain rod to two corners of the room. If the drapes are positioned far enough away from the corner, the space can be utilized for storage of folding chairs and other items, thus adding a usable storage area. In this manner, the room is no longer square or rectangular, and its reverberant nature will be reduced.
2. Hang light attractively colored drapes to the sides of windows (not over the windows), the length being two to three inches above each window, and about six to eight inches below the window. Or, if there are no windows, hang decorative light floor-to-ceiling drapes at a few strategic locations on the walls of the room. Colors that blend or complement the existing colors of the room will add to the attractiveness of the environment. Colors such as lavender or rose will generally compliment beige or cream color walls.
3. If the ceiling is higher than most rooms, hang attractive decorative flagging periodically across the ceiling to reduce echoes.
4. Note: For items 1-3, it is important to not overdue. Do not make a reverberant environment into an anechoic chamber. Moderation is important. Some "life" in the room is important—we just do not want too much!
5. Muffle irrelevant noise. If there is a pop machine, ice maker or water fountain nearby, make sure that it is either muffled, or quieted to the degree possible. If neither of those options are possible, have them moved to another location.
6. If there is an area that is used for food preparation attached to or near the meeting room, use heavy drapes to block off that area to quiet the noise of pots and pans, people talking and so on. If the money is available, add a wall with a sliding door to block off that area.
7. Make sure that the PA system is adequate. A poor or unused PA system can be one of the greatest detractors to successful meetings, particularly when there is to be a speaker for the program, or the secretary is to read the minutes of the previous meeting along with the treasurer's report, etc.
8. Instruct speakers and others on how to use the microphone. Most microphones in meeting rooms, church sanctuaries, and other places where people congregate are designed as "high impedance" in their construction, meaning that they resist the voice signal. These microphones must be held within 3 to 4 inches from the mouth to be useful in most meeting areas. If the amplifier is turned up to compensate for a microphone that is held further than 3-4 inches from the mouth, "acoustic feedback" which is heard as a squealing or whistling sound will be emitted and can be quite disturbing to the listeners. The amplifier and speakers must be far enough away from the microphone to prevent that from occurring.
9. Coach those who are to speak before an audience at a meeting, including ministers, and even those who read the minutes of the previous meeting. Coach them on how to speak with clarity! This can be done very simply by coaching them to slow their rate of speech. Persons age 60 years and older can understand speech best when it is uttered at a rate of around 124 words per minute (Robinson and Hull, 2015)2. The average public speaker, teacher, family member, business person and others are generally found to speak at a rate of around 160-180 words per minute! The human central auditory nervous system is simply not designed to process and comprehend speech that is uttered at that rapid rate.

If the reader has watched the early television shows of Mr. Roger's Neighborhood, or listened to Paul Harvey, or Walter Cronkite, or Tom Brokaw, it is important to realize that one of the important reasons they were so easy to hear and understand, and therefore added to their popularity with their viewing audience is because they practiced speaking at a rate of around 124-126 words per minute. Advise speakers to emulate those

professionals, and not only will their rate of speech assist their listeners in understanding what they are saying, but also by slowing their rate of speech, speech clarity will tend to increase fairly significantly.

10. Advise those who are responsible for banquets or other dinner functions to avoid background music, or MUSAK, in the listening/communicative environment, no matter how one might feel that it will "set the mood" for the event. It becomes a detractor to the transmission of speech, and at the least it interferes with speech understanding.

Homes

As stated earlier, many homes are literally anechoic chambers. In some instances, a commercially designed anechoic chamber for acoustic research could not have been designed much more efficiently. Speech does not travel well in that type of environment. Sound, particularly a complex set of acoustic signals such as speech, is absorbed rather than transmitted to the listener. These environments are just the opposite of the overly reverberant environments described earlier. Speech may not be able to travel far enough to be heard or understood well. People who live in those homes probably did not furnish them on purpose so that they would restrict the transmission of speech signals. It was perhaps because they didn't know about the impact of softness and absorbency on the transmission of speech. In designing the interior of their home for comfort, so much softness and texture may have been added that sounds, particularly the complex sounds of speech are absorbed by the padding and fabric.

People generally entertain in the living or family room. Typically these rooms are not ideal environments for conversation particularly if they contain soft overstuffed furniture, carpeting, drapes, or textured wallpaper, textured ceilings, and perhaps some background music added, all making communication difficult because the physical complexities of speech are absorbed in those environments.

Here are some suggestions for a home environment that will enhance the transmission of the acoustical characteristics of speech, and therefore enhance speech understanding:

1. As stated above, while church sanctuaries and meeting rooms and many other such environments may be "reverberation chambers", homes are generally without sound carrying characteristics due to the softness and fabric of overstuffed furniture, drapes, carpeting, and other absorbent obstacles that are found in a home that restrict or absorb the complex acoustic signals that comprise speech. In that environment, it is difficult for the sounds of speech to efficiently travel further than about 7 feel in a straight line.

2. While one does not desire to ask home owners to completely renovate their home to remove the texture and softness of the living environment, some minor changes can be made to enhance the transmission of the sounds of speech. Those can include **(a)** replacing heavy carpeting in a room that is used as a place of conversation when visitors come with attractive laminated wood, but with throw rugs to keep a feeling of warmth in the room; **(b)** replacing heavy drapes with lighter material, or attractive window blinds; or perhaps **(c)** replacing couches and over-stuffed chairs for ones that have greater firmness.

3. When communication is to take place, turn down (or off) the TV or radio when conversing with another person, particularly if the person with whom one is conversing possesses impaired hearing that may be accompanied by a decline in central auditory function.

4. Do not attempt to communicate when speaking to another person who is located around the corner in another room, up stairs, down stairs, or on the other side of an open doorway. The sounds of speech cannot travel well through or around any of those obstacles.

5. To assure that the person with whom communication is taking place can truly be expected to hear and understand what I being said, advise others to not speak unless the other person can see the face of the speaker, again not from another room, or while walking away from the listener.

6. Careful attention must be given to lightening. With aging, the color of the lens of the eyes change, and likewise the speed of dilation or contraction of the iris begins to slow. Further, eye color takes on a more opaque coloration. So, glare and movement from a brighter environment to one with less light, or from less light to a brightly lit environment can be problematic since it becomes more difficult for older adults to use their eyes for purposes of communication when there may either be too much or too little light in the communicative environment.

SUMMARY

In order to prevent otherwise minor impairments of hearing from appearing greater than they are, we must work in terms supportive architecture, thereby preventing unnecessary impairments of hearing, vision, mobility, social competence, and mental competence. Adults with impaired hearing and aging visual systems do not, of course, desire to appear as though they are demented, or impaired to a greater degree than they truly are. But, many environments that we offer them in which listening and communication is intended to take place can result in what may be relatively minor impairments becoming unnecessarily amplified. Therefore, we can offer a tangible service that provides almost immediate rewards.

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Cite this article

Hull RH (2019) Enhancing Communication through Environmental Design for Adults Who Possess a Decline in Peripheral and Central Auditory Function. J Ear Nose Throat Disord 4(1): 1039.