Speech Perception by Elderly Listeners: Basic Knowledge and Implications for Audiology

Perception de la parole par les personnes âgées : connaissances de base et implications audiologiques

by • par

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ABSTRACT

The basic research and audiological findings on the effects of the normal aging process on speech perception and word recognition abilities are reviewed. The impact of these results on the interpretation of audiometric test results and the anticipated impact of auditory aging on the rehabilitative needs of older listeners is discussed.

ABRÉGÉ

On examine les résultats de la recherche et les principales conclusions audiologiques sur les effets du processus normal de vieillissement sur la perception de la parole et de la reconnaissance des mots. On étudie l'incidence de ces résultats sur l'interprétation des résultats audiométriques ainsi que l'incidence prévue du vieillissement auditif sur les besoins des auditeurs âgés en matière de réadaptation.

KEY WORDS

aging • speech perception • word recognition • presbycusis

Hearing loss associated with aging commences as early as the third decade of life (Davis, 1989). In general, such hearing deterioration is initially very gradual, averaging less than 5 dB per decade for women under 60, and increasing to 15 dB per decade for men 80 years and older, in the frequency region above 1000 Hz (Gates, Cooper, Kannel, & Miller, 1990; Moscicki, Elkins, Baum, & McNamara, 1985; Pearson et al., 1995).

These statistics are based on the average changes in hearing sensitivity in a large number of people. For any individual, such small declines in sensitivity would rarely be detected until late in life, after a more substantial, cumulative hearing loss has occurred (Royster & Royster, 1991). This is to say that, for the average healthy individual, audiologically significant hearing losses — those that would invite attention by an audiologist — would not, *on average*, occur until the sixth or seventh decade of life, by which time an individual's hearing sensitivity as measured by pure tone average, may have decreased by 15-25 dB from young adult values.

Nonetheless, decreases in hearing sensitivity of 25 dB or less in the mid-frequency range may make a substantial difference in a listener's ability to understand speech, particularly in adverse listening conditions, such as those found in shopping malls, restaurants, dinner parties, large and small meeting rooms and many offices.

In this paper, the effects of aging on speech perception and word recognition abilities and the implications for audiologists and elderly persons will be discussed. First, the speech perception and word recognition abilities of individuals who acquire hearing loss as they age will be reviewed — a topic that receives much attention in geriatric audiological research and rehabilitation — as well as the potential impact of auditory system aging on speech perception and word recognition for individuals who have normal or good hearing for their age by conventional audiometric standards.

Research in the past decade has been devoted to studying the effects of aging on the auditory system; in these studies and review papers both normal and pathological processes are described. Several useful textbooks have been published recently that provide a resource for audiologists who provide services to elderly persons (Hull, 1995; Kricos & Lesner, 1995; Willott, 1991). This increased profile of hearing and aging issues has not yet resulted in major modifications to Canadian audiology and speech-language pathology curricula. A recent survey reports that audiologists get most of their knowledge about the topic via on-the-job experiences and after formal education has been completed (Orange, MacNeill, & Stouffer, 1997). Such learning is likely to be strongly influenced by the peculiarities of the caseload of each audiologist and the nature of their audiological education, but less directed by current research and theoretical developments.

At the same time, there has been a rapid increase in the theoretical and empirical knowledge of the effects of aging on hearing and speech understanding, motivated by our awareness of the demographic trends in our aging population and the willingness to allocate funding to improve our understanding of aging processes. What have these research programs uncovered that can be applied to the daily clinical practices of audiologists? How can they be used to assist in the interpretation of audiometric results, improve service delivery to clients, and increase the benefits of audiology and speech-language pathology services to older clients? Following the summary of age-related changes to speech recognition performance, these issues will be addressed in this paper.

Major reviews of the literature on the effects of aging on speech perception have been provided by Bergman (1980), Marshall (1981), Moller (1983), Willott (1991), and the Working Group on Speech Understanding and Aging (Committee on Hearing, Bioacoustics, and Biomechanics, 1988), among others. These reviews have reported the normal and pathological effects associated with the aging auditory system and the impact of these aging effects in quiet, noise, distortion, and other degraded-speech listening conditions. Without attempting to reiterate the complex set of results reviewed in these resources, the following summary statements of the literature base should suffice to provide background for further discussion.

Presbycusis is a predominately bilateral, sensorineural, high-frequency hearing loss. On average, men have better low-frequency thresholds (<1000 Hz) than women up to age 30, but women have better high-frequency thresholds (Pearson et al., 1995). Women continue to have lower high-frequency thresholds throughout the life span (Gates et al., 1990; Pearson et al., 1995). These gender differences increase slightly with increasing age, because of differences in the rate and time course of threshold changes for men and women. Some research results have not confirmed the existence of gender-related differences in the rate of sensitivity decline (Davis, 1989), but gender differences in pure tone thresholds are not disputed. In general therefore, the decline in auditory thresholds can be approximated as 1 dB per year (Brant & Fozard, 1990).

Along with the decline in pure tone hearing sensitivity, changes in word recognition performance occur on tests that form a part of standard audiological evaluations. Speech reception thresholds (SRTs) increase at a rate comparable to pure tone threshold increases (Grady et al., 1984). Suprathreshold word recognition performance also declines with age. Word recognition scores (more commonly referred to clinically as word discrimination scores) decline faster in males than females (Gates et al., 1990). For W-22 words presented at 50 dB HL, word recognition accuracy declines by 13.2% per decade in men and 5.6% per decade in females for persons over 60 years. Recent evidence has confirmed that most of the decrease in word recognition testing results can be attributed to individual changes in hearing sensitivity per se, rather than declines in auditory processing abilities, as measured by the test battery of auditory capabilities (Humes et al., 1994), or cognitive functioning (Humes et al., 1994; Jerger, Jerger, Oliver, & Pirozzolo, 1989; Jerger, Stach, Pruitt, Harper, & Kirby, 1989). However, central processing and cognitive decline may have a negative impact on word recognition scores in a small percentage of older persons (Committee on Hearing, Bioacoustics, and Biomechanics, 1988; Jerger, Jerger, et al., 1989).

Marshall (1981) has described how the interpretation of word recognition results in older listeners is made difficult because of the influence of testing level on performance scores. Most word recognition testing is conducted at a fixed level above the SRT, usually 30 to 40 dB above SRT. However, the SRT depends primarily on low frequency thresholds (Jamieson, Cheesman, & Corbin, 1994), whereas good word recognition performance depends on audibility across a wide range of frequencies, including the high frequencies which are most affected by the aging process (Cheesman, Hepburn, Armitage & Marshall, 1995). The common audiological observation that many older persons have poorer word recognition scores than their pure tone thresholds would indicate may be a reflection of the use of SRTs to select the test level for word recognition tests and the use of pure tone averages (PTA; average threshold at 500, 1000 and 2000 Hz) to describe a person's hearing sensitivity, when the hearing loss is sloping or confined to higher frequencies. In such cases, the overall effect of a hearing loss on speech understanding is poorly described by both the PTA and the low- to mid-frequency based SRT.

Maximum word recognition scores (PBmax) may occur at levels higher than 40 dB SL in elderly persons (Plath, 1991); yet for persons over 80, rollover is also likely to occur at higher sensation levels (Gang, 1976). Marshall (1981) has concluded that "the level that speech is assessed relative to the level where maximal speech intelligibility would be obtained may greatly influence the results of speech intelligibility measures. Testing at a fixed SL certainly does not equate functional listening level, as has been the intent" (p. 225). Again, this discrepancy between expected results and commonly observed patterns in elderly persons may be caused by the absence of a strong relationship between the measure used to define the sensation level (SL) used for word recognition testing and the word recognition task demands which depend on thresholds over a broad frequency range.

When research is conducted with listeners who have normal hearing thresholds, subtle differences in hearing sensitivity may exist between younger and older subjects. Despite researchers' intentions to control for hearing thresholds by using only subjects with normal hearing thresholds, the range of normal hear-

ing is sufficiently wide that research subjects may not be completely matched on the basis of hearing thresholds, with the tendency for the older listeners in a research sample to have slightly higher thresholds than younger listeners (Cheesman et al., 1995; Gelfand, Piper, & Silman, 1986; Gordon-Salant & Fitzgibbons, 1995; Kamm, Morgan, & Dirks, 1983). Furthermore, other changes in auditory processing occur with advancing age such as temporal and frequency resolution loss (c.f. Schneider, 1997), and changes to central processing systems (e.g., Patterson, Nimmo-Smith, Weber, & Milroy, 1982; Pichora-Fuller, 1997). These may occur in the absence of any measureable increase in auditory thresholds (Peters & Moore, 1992; Schneider, 1997).

Because the measurement of speech perception ability in noise or reverberation is not performed routinely in audiometric assessment, the difficulties of listening in noise or reverberation for an elderly client are not commonly known; typical pure tone and speech-in-quiet assessments certainly underestimate performance under difficult listening conditions and may be poor predictors of such performance for many persons. Furthermore, hearing assessment of elderly persons is not routine in the Canadian health care system, so that only those elderly persons who specifically present with a hearing or hearing-related problem have their hearing assessed systematically. Despite these limitations, laboratory research has been helpful in characterizing age-related changes in speech perception and word recognition abilities, both in quiet and degraded listening conditions. This research has led to a better understanding not only of the speech understanding abilities of older persons who have an identified hearing problem, but also for older persons with relatively good hearing sensitivity, who would not ordinarily seek an audiological assessment.

Larger differences in speech perception abilities between younger and older listeners exist when the speech stimuli are presented in degraded listening conditions than when the stimuli are presented in quiet (Pederson, Rosenthal, & Moller, 1991; Plath, 1991). Older listeners consistently perform poorer than do younger listeners on speech perception tests in which background noises are present or when some of the speech content has been removed by filtering (for example, Cheesman et al., 1995; Helfer & Wilbur, 1990; Smith & Prather, 1971). Older listeners are affected more by masking noise than would be predicted by the masking effects of noise on the audibility of the speech alone (Dubno, Dirks, & Morgan, 1984; Hargus & Gordon-Salant, 1995; Humes & Roberts, 1990; Schum, Matthews, & Lee, 1991) and require up to a 4 dB greater signal-to-noise ratio (SNR) when the SRT is measured in noise than younger listeners require (Humes & Roberts, 1990; Patterson et al., 1982; Plomp & Mimpen, 1979). The pattern of speech perception errors, as determined from the consonant confusions made by the listener, remains the same in younger and older persons, although the number of errors generally increases with age (Cheesman et al., 1995; Gelfand et al., 1986; Gordon-Salant, 1987; Helfer & Huntley, 1991).

Studies in which alterations to speech have created highly artificial listening conditions, such as in dichotic listening tasks, speeded speech understanding tasks, and temporally disrupted sentence recognition, have generally shown older listeners to be more dramatically affected by speech distortions than are younger listeners. For persons who have normal hearing thresholds, age differences are observed when only mild distortions are made to the speech; when hearing-impaired listeners are tested, older listeners perform more poorly than younger listeners only when the speech is severely distorted (Gordon-Salant & Fitzgibbons, 1995). Thus older listeners with good hearing are relatively more affected by speech distortions than older listeners who have a hearing loss when compared to younger listeners with the same hearing sensitivity.

Slower auditory temporal processing in older persons (Gordon-Salant & Fitzgibbons, 1993, 1995) creates more problems in processing temporally distorted speech than occurs for younger listeners. Indeed, older listeners need a longer temporal window in order to understand time-gated words (Craig, Kim, Pecyna Rhyner, & Chirillo, 1993).

Although many of the observed declines in speech communication can be attributed to changes in the audibility of speech caused by decreased hearing sensitivity that accompanies aging, the poor performance of older listeners when speech is further degraded is not explained by audiogram changes or the acquisition of other auditory or cognitive processing deficits (Humes et al., 1994). Moreover, the effect of combined distortions is greater than would be predicted from the additive effects of the individual distortions alone (Gordon-Salant & Fitzgibbons, 1995).

To explain these results, Gordon-Salant and Fitzgibbons (1995) have proposed that older listeners perform on speech tests as if they had a lower functional SNR than younger persons. They describe functional SNR as the effective SNR of speech when external noise (noise from the environment) as well as internally produced (system) noise are combined. This functional SNR may be influenced by decreased internal signal strength in the aged auditory system, by increased neural noise, or by a combination of these two factors. The implication of their proposition is that aging effects can be modelled as if there were more noise added to the speech after it is received. Lutman (1991) has described this phenomenon as "excess" disability or a disability that is greater than that which would be expected on the basis of the hearing impairment alone.

Self-perceived speech perception abilities. Despite clear evidence that both speech perception abilities and word recogni-

tion performance decline with increased age, changes in self-perceived speech communication abilities, as assessed by responses on hearing-handicap questionnaires, do not reflect this decline. For a given audiometric hearing loss, older listeners report that they have less handicap than do younger persons with the same hearing loss (Gatehouse, 1991; Gordon-Salant, Lantz, & Fitzgibbons, 1994; Lutman, Brown, & Coles, 1987). These result imply either that people become less affected by hearing loss as they age or that they under-report the handicap they may experience. The former explanation is not supported by the literature summarized above, documenting communication performance decrements associated with increased age. The alternative explanation, that handicap is under-reported, may be due to a lack of awareness of changes in the individual's hearing abilities, changes in the expectations of communication competence, changes in communication needs or communication environments, or some combination of these and other factors.

Implications for Audiology

The recent advances in our understanding of the relationships between age, audiometric measures, speech perception and word recognition performance, and self-reported speech communication functioning indicate a need for caution when audiological test results for elderly persons are interpreted.

Conventional word discrimination testing at a fixed level relative to SRT is based on a faulty assumption that this protocol will result in word discrimination testing at a fixed sensation level for all persons. However, as noted earlier, there is only a slight relationship between low and high frequency thresholds in a typical person with presbycusis. Word discrimination testing requires audibility of high frequency speech components whereas SRT is dependent upon thresholds at lower frequencies.

The absence of a clinically significant elevation in hearing thresholds by itself does not indicate a lack of hearing disability. In their study of the relationship between hearing impairment, disability and handicap in the elderly, Bess, Lichtenstein, and Logan (1991) have concluded that "even milder forms (17-26 dB HL) of hearing impairment appeared to be related to poorer function" (p. 228).

Findings indicate that (a) older listeners tend to report less handicap than younger listeners with the same audiometric hearing loss, (b) there is an inverse relationship between speech perception performance measures and age, and (c) the deleterious effects of noise and reverberation are exacerbated with increasing age. Therefore, audiologists should expect that the effective handicap of older adults will be greater than that indicated by either audiometric test results or patient self-report.

This complex set of associations helps explain why relatively few elderly adults seek audiological services and why there is such a paucity of auditory rehabilitation services for older persons (Davis, 1991; Herbst, 1986). Furthermore, they suggest that many, if not most, elderly persons might derive benefit from audiological services that are usually provided only to persons with significant hearing loss or persons who are identified as hearing aid candidates. If the reason that older persons under-report the handicap they experience is because they are unaware of their hearing decline or changes in their expectations of their own communication abilities, then aural rehabilitation services and information may be of benefit to many. On the other hand, if the apparent under-report of hearing handicap is caused by a true lack of difficulty in communication, as may occur if their communication needs and environments are much different from younger persons, then such services may be of limited value for many older persons.

Even elderly persons whose hearing could be labelled as normal for their age might be able to take advantage of communication enhancement strategies to assist them in difficult communication environments. Communication enhancement strategies specifically developed for older hearing-impaired listeners (Hull, 1995; Kricos & Lesner; 1995) may assist a broader range of older persons than currently receive this form of rehabilitation.

Implications for Elderly Persons

Elderly adults, and those who serve their health care needs, are not generally well informed about hearing and hearing health (Garstecki, 1996; Humphrey, Herbst & Faurqi, 1981; Parving, Christensen, & Sorenson, 1996). Yet hearing ability and, in particular, speech perception and word recognition abilities may seriously affect a person's sense of belonging in a social world, and thereby influence social and emotional behaviours (Vesterager, Salomon, & Jagd, 1988). Even a mild hearing loss has been shown to negatively affect both speech communication (Bess, Lichtenstein, & Logan, 1991; Garstecki & Erler, 1995) and a person's sense of competence in everyday living (Garstecki & Erler). Controlled comparisons of elderly new hearing-aid users and non hearing-aid users have demonstrated the general effectiveness of hearing aids in increasing speech understanding and improving emotional and cognitive performance as measured by hearing handicap and affect scales (Mulrow et al., 1990; Weinstein, 1991). Thus audiological rehabilitation services have been demonstrated to have cognitive and emotional benefits.

Hiatt (1985) acknowledged the need for improved communication spaces in creating barrier-free housing for elderly persons because "background noise is as serious an obstacle to the transactions of older persons as steps are to the movement of a person requiring a wheelchair" (p. 210). In her report, she was referring to older adults, and not specifically to older persons who have a hearing loss. Possible modifications that can be made to the

environment to improve speech perception are changes to lighting to aid with speechreading, sound absorptive rooms (short reverberation times), increased availability and use of assistive listening devices, removal of stigma that prevent persons from asking for assistance and clarification, and increased public awareness of strategies for communication.

Unfortunately, even the best-intentioned health care professionals are not actively aware of the speech communication difficulties encountered by many older adults. For example, conference activities specifically designed to involve elderly people are too often scheduled in rooms that prevent persons with even mild hearing difficulties from hearing all that is said.

Conclusions

1. For a given hearing level, older adults are more disabled, yet report a lower level of communication handicap than their younger counterparts. As the average age of the Canadian population increases and as these older Canadians are becoming more active consumers of health care in general (Elliot, Hunt, & Hutchinson, 1996), the role of audiologists and speech-language pathologists will change. It may no longer be sufficient to be aware of the communicative difficulties encountered by older adults with significant hearing losses. Instead, rehabilitative audiology services may be required by a large number of older persons whose hearing is audiometrically normal or near normal. Improved assessment of speech perception abilities, counselling, communicative strategies training, personal amplification, and assistive listening device services may be desirable for persons who are not currently receiving audiological services, but nonetheless have audiological needs that otherwise might remain unmet.

2. Pure-tone testing, speech reception threshold measurement, and word discrimination testing in quiet are likely to underestimate the degree of handicap that elderly persons experience when trying to understand spoken language in real life environments. Audiologists, speech-language pathologists, and other professionals need to educate others, particularly other health care professionals, about the potential impact of such hearing and speech perception changes on behaviour. For example, misinterpreted results of medical tests may occur, or failure to comply with physician, spousal, or audiologist requests may actually be a failure to hear or ask for clarification of misheard directions (Salomon, 1986).

3. There is a need for an increased awareness of the incidence of hearing loss in older persons and an understanding that, despite having relatively good hearing as defined by conventional audiometrical criteria, a person's ability to hear can interact with the acoustic conditions in everyday environments and can create handicapping situations. The effects of this interaction on communication performance will increase with age.

4. Concurrent with the need for increased awareness of the special hearing difficulties of older adults is the need to advocate for improved communication environments for elderly persons, so that known barriers to speech communication are reduced or eliminated.

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