AUDITORY AND COGNITIVE AGING: IMPLICATIONS FOR HEARING ACCESSIBILITY

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1 Introduction

It is well known that the population is aging and that hearing loss and cognitive loss become more prevalent with age. Importantly, laboratory and epidemiological research suggests that there is a connection between hearing and memory declines in older adults. This connection is found in people who have clinically normal hearing and cognition, as well as in those who have impairments. The reasons for the connection are not yet known. Hearing problems in adverse communication environments may accelerate social withdrawal and, in turn, cognitive decline. Conversely, good communication and social interaction may be an important part of promoting healthy and active aging. This paper will provide a brief review of auditory and cognitive aging research, with an emphasis on implications for the design of accessible environments to promote and maintain active communication and social participation by older adults.

2 Auditory and Cognitive Aging

2.1 Auditory Aging

Hearing loss, defined by audiometric thresholds, is one of the three most common chronic disabilities in older adults [1]. Pure-tone threshold loss increases slowly with age [2]. By the age of 65 years, about a third have a clinically significant loss, by the age of 75 years about half are affected, and by the age of 80 most people are affected [3].

Importantly, the earliest signs of age-related hearing loss (ARHL) may be difficulty understanding speech in noise. Such difficulties due to problems in supra-threshold auditory processing problems are usually noticed before clinically significant threshold elevations are diagnosed.

There is heterogeneity in the hearing abilities of older adults. Many older adults have sensori-neural hearing loss due to damage to cochlear outer hair cells (OHCs); however, this type of hearing loss often results from exposure to noise and is not unique to aging. In ARHL, multiple structures in the cochlea and central auditory system can be damaged in ways that do not involve OHC damage and that are not typical in younger adults. The high-frequency threshold elevations typical of the audiograms of older people may result from changes in the endocochlear potentials related to damage to the stria vascularis or blood supply to the cochlea [4]. Neural damage may also occur, with associated reductions in supra-threshold auditory temporal processing, even if there is little or no change in audiometric thresholds [5]. Thus, there is much variability in the degree of difficulty that older listeners experience in everyday life. Their speech-in-noise performance is often poorly predicted from the audiogram and their problems may not be solved readily by simply amplifying sounds.

2.2 Cognitive Aging

As healthy older adults age, some aspects of cognition get worse, but others get better [6]. There are gradual declines in the ability to process information such that it becomes more difficult for older listeners to attend to, understand, and remember what they have heard. However, there are also gradual gains over the adult lifespan in knowledge of the world, linguistic knowledge (e.g., vocabulary), and other types of expertise. Older listeners may compensate for difficulties processing information by using knowledge to advantage. Beyond normal age-related cognitive changes, clinically significant mild cognitive impairment and dementia increase with age, such that the age of 70 years, about a fifth of people have a clinically significant cognitive loss [7].

2.3 Auditory-Cognitive Links

Adults of any age have more difficulty paying attention and remembering when they listen in noise compared to when they listen in quiet. Accordingly, at least some of the cognitive problems of older adults are aggravated by ARHL and the mental challenges of listening in noisy situations [8]. Over decades of living with hearing loss, ARHL also seems to put people at greater risk for dementia [9-11]. Indeed, some studies have found that individuals with hearing loss had a 2 to 5 times increased risk of developing dementia [12] and that for every 10 dB of hearing loss over 25 dB HL, individuals had a 20% increase in their risk of developing dementia [13]. More research is needed to discover the reasons for the links between hearing loss and cognitive loss [14].

Some evidence suggests that hearing rehabilitation could contribute to cognitive health [15], but well-controlled studies to test this idea are just beginning. In the meantime, seeking help for hearing problems may be a good idea. It is also more important than ever to consider the special auditory and cognitive needs of older adults when designing hearing accessible acoustical spaces for communication consistent with age-friendly social policies.

3 Listening Needs

3.1 Auditory Considerations

To match the performance of younger adults on tests of word recognition in multi-talker babble, older adults with good audiograms typically need a signal-to-noise ratio (SNR) that is about 3-4 dB more favourable, and those with high-frequency hearing loss typically need an SNR that is about 9 dB more [16]. Of course, energetic masking occurs when the spectra of the target speech and the masker are similar. However, the temporal properties of the masker are

also important to consider because older adults often have reduced auditory temporal processing abilities. Compared to listening situations in which the background noise is relatively steady, age-related differences are greater if the background noise fluctuates because it is more difficult for older listeners to detect temporal gaps and to glimpse a target speech signal in the gaps of a fluctuating masker. Furthermore, age-related differences are even greater if the background noise is the speech of one talker, partly because the content of what is being said by the competing talker may be distracting, and partly because it becomes more difficult to segregate speech streams when their spectral and temporal acoustical properties are more similar, thereby increasing 'informational' masking. In particular, age-related difficulty increases if the target talker and competing talker(s) are of the same gender, probably because older listeners can have reduced ability to use periodicity cues to separate speech streams based on between-talker differences in the fundamental frequency and harmonic structure of the voices [17]. In terms of using binaural cues, older adults are also less able than younger adults to use spatial separation between a target and competing talker to separate speech streams [17].

3.2 Cognitive Considerations

Problems hearing in challenging conditions are compounded because the listener must allocate more cognitive resources to pay attention, understand, and remember information that has been heard. The demands on attention are even greater when listening is not the only task. Even ordinary multi-tasking such as listening while walking (possibly when using a mobility device such as a walker) can require the person to divide attention to an extent that may be related to the finding that older people with hearing loss are at greater risk of falls compared to peers with good hearing [18].

4 Conclusions

In general, hearing accessibility improves if communication environments are less noisy and reverberant. For older adults, in addition to reducing relatively steady background noise sources, it will be important to design environments to facilitate the ability of listeners to focus on a target talker and ignore the distracting, competing voices of others sharing the same space. Acoustical designs may also need to take the multi-tasking demands on older users into account if they need to move or do other tasks while listening.

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