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Review

Acceptable noise level as a deciding factor for prescribing hearing aids for older adults with cochlear hearing loss – A scoping review

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Abstract

Older adults often find it difficult to perceive speech, especially in noisy conditions. Though hearing aid is one of the rehabilitative devices available to older adults to alleviate hearing loss, some of them may experience annoyance through hearing aid and hence reject it, may be due to circuitry noise and/or background noise. Acceptable noise level is a direct behavioural measure to estimate the extent of how much a person is able to put up with noise while simultaneously listening to speech. Acceptable noise level is a central auditory measure and it is not influenced by age, gender, presentation level or speaker. Using this measure, we can quantify the annoyance level experienced by an individual. This information is of utmost importance and caution should be paid before setting the parameters in hearing aid, especially for those who are unable to accept noise. In this review article, an attempt has been made to document how to optimize the hearing aid program by setting parameters such as noise reduction circuit, microphone sensitivity and gain. These adjustments of parameters might help to reduce rejection rate of hearing aids, especially in those individuals who are annoyed by background noise.

Keywords: Annoyance; Amplification; Speech perception in noise; Older adults; Hearing impairment

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Hearing loss in the elderly population is most common due to presbycusis and other related systemic illness. According to World Health Organisation (WHO) global estimates on prevalence of hearing loss in 2012, approximately one-third of persons above 65 years are affected by disabling hearing loss. There are 164.5 million persons of above 65 years with disabling hearing loss, i.e. 33% of the world's population above 65 years (WHO, 2012). Hearing aids are the major form of rehabilitation to older adults with sensorineural hearing loss. However, the speech perception of older adults through hearing aids varies depending on a number of factors.

1. Speech perception in noise by older adults with hearing loss

Cochlear hearing impairment individuals often complain of understanding speech, especially in background noise. Frequency selectivity is usually reduced in individuals with cochlear hearing loss. In addition, temporal resolution is impaired, especially in advanced age accompanied with hearing loss (Glasberg and Moore, 1989). There are several researchers who studied speech recognition in cochlear hearing loss at different signal-to-noise ratios (SNRs) (Glasberg and Moore, 1989; Festen, 1987; Festen and Plomp, 1990; Plomp, 1994; Festen, 1993; Moore, 1995; Grant and Walden, 2013). Their results suggest that individuals with cochlear hearing loss required higher signal-to-noise ratio (SNR) levels to achieve same performance as normal hearing individuals. In addition, difference in speech recognition threshold (SRT) for normal and hearing-impaired individuals varied greatly depending on the nature of the background noise. When the background noise used was speech-shaped noise, the speech recognition threshold in noise (SRTn) difference between normal and hearing-impaired individuals ranged from 2 to 5 dB (Glasberg and Moore, 1989; Plomp, 1994). Whereas, in other background noise such as single competing talker, time-reversed talker or an amplitude-modulated noise, the difference in SRTn was much larger, ranging from about 7 dB up to about 15 dB (Souza and Turner, 1994; Peters et al., 1998). Thus, speech recognition in noise for cochlear hearing loss individuals varies based on the type of background noise, which masks the temporal and spectral contents of speech. Further, in case of informational masking such as single talker and four talker babble, individuals with cochlear hearing impairment fail to take advantage of "dips" in the competing voice. These dips may be of two types: temporal and spectral. Temporal dips are momentary fluctuations in overall signal-to-noise ratio, especially during brief pauses in speech or during production of low energy sounds. In the region of temporal dips, the signal strength is found to be relatively higher than that of background noise and this allows brief 'glimpses' to be obtained from the target speech. The spectral dips arise because the spectrum of the target speech is usually different from that of the background speech measured over any short interval. Although parts of the target spectrum may be completely masked by the background, other parts may be hardly masked at all. Thus, parts of the spectrum of the target speech may be "glimpsed" and used as cue to follow speech in competing noise. Studies have reported possible factors in the reduction of speech recognition in noise (Van Tassel, 1993). Cochlear hearing loss subjects have broadened auditory filters. Wider auditory filters do not mean that it removes information from speech; rather it impedes the transfer of spectral and temporal information. It can be expected that spectral peaks and valleys in stimulus are smoothed out in those individuals with sensorineural hearing loss (SNHL). In addition, upward spread of masking is common i.e., the higher frequency components of speech are masked by the higher amplitude of vocalic sounds or maskers of low frequencies, which is found to be one of confronting factors in SNHL. It was also speculated that only few auditory filters are available for analysis but noise accompanied with stimulus taxes these available filters such that noise accumulates in functioning filters leading to reduced recognition in lesser SNRs. It infers that older adults find it difficult to follow speech in adverse listening conditions. One among the rehabilitative device available to them is hearing aid. There are several measures to assess the aided performance from them. Speech recognition threshold is one such measure which reflects the aided benefit. In addition, outcome measurement scales are used to document the satisfaction index from hearing aid. Unfortunately, there was no relationship between the score on speech intelligibility in noise and his or her real world benefit and/or satisfaction with hearing aids. Majority of hearing aid users reject their device because of background noise through they have had good recognition scores (Kochkin, 2010). It is of utmost importance to measure the amount of annoyance experienced by the hearing impaired subject.

2. Estimation of annoyance towards noise using ANL

Acceptable noise level is the measure of whether the subject is able to put up with noise while simultaneously listening to speech at their most comfortable listening level (Nabelek et al., 1991). This method of quantifying background noise acceptance is termed "acceptable noise level" (ANL). Based on acceptance towards noise, ANL is classified into three groups. Individuals who receive ANL values of <7 dB HL, >13 dB HL and between 7 dB HL and 13 dB HL