The Natural Sounds Loudness Estimation Method Applied to Patients with “Dead Regions” – Preliminary Study

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Abstract

It is a well known fact that hearing aids fitted using classic methods often does not bring expected benefit to hearing impaired people with “dead regions”, (DRs). We propose an alternative method of hearing aids fitting for such patients, based on perception of natural sounds - The Natural Sounds Loudness Estimation (NSLE) method. For patients with diagnosed DRs hearing aids were fitted using the NSLE and, for comparison, with two classic methods (NAL-NL1 and POGO). Estimated insertion gains (IGs) were different for these two classes of fitting methods. IGs estimated using NSLE were generally lower than gains estimated by classic methods. Subjective comfort of hearing aids fitting was checked by the APHAB test. Results the APHAB test have clearly shown that patients with DRs have preferred fitting based on the NSLE method. Thus, the NSLE method seems to be a good option of hearing aids fitting in the case of people with DRs.

Keywords: hearing aid fitting, dead regions

Introduction

People with hearing disorders often complain about the quality of sound produced by hearing aids they use and difficulties in speech intelligibility in noisy conditions. Thus, hearing aids are not often effective and helpful devices and their usefulness is limited. In majority of situations it is not possible to obtain speech intelligibility “as it was before”, especially in the case of serious hearing problems of sensorineural origin. Thus, the main aim of the audiologist is to fit a hearing aid to obtain the best possible speech improvement for a given hearing loss, or in other words to optimise hearing aid fitting procedure. Optimisation means: proper diagnosis of the impairment, taking advantage of modern hearing instruments (multi-channel, digital) and a choice of the adequate hearing aid fitting method. In our work we concentrated attention on the latter factor in the aspect of DRs.

By definition the areas of the basilar membrane where inner hair cells are completely non-functioning or even missing and/or neurones innervating those places are non-functioning or degenerated are called “dead regions” [1]. A “dead region” is defined in terms of the characteristic frequencies of the inner hair cells and/or neurones immediately adjacent to the dead region. Basilar membrane vibration in such regions is not transduced and does not lead to action potentials in the auditory nerve. It is usually not possible to predict the occurrence of DRs based on a tonal audiogram [2] and specific methods of diagnosis must be used (psychophysical tuning curves (PTCs), threshold equalizing noise method (the TEN test), [2] and fast PTCs). Classic hearing aid fitting methods which ignore the presence of DRs are often unsuccessful and hearing aids fitted using such methods do not improve or sometimes worsen a life comfort of hearing impaired people.
Method – natural sounds loudness estimation (nsle)

The NSLE method belongs to the class of interactive procedures based on perception of natural signals, similarly to A-Life or Scaladapt methods. The method was proposed by Hojan, Geers, Jezierska, [3]. The method combines the assumptions of the Würzburger Hörfeld Skalierung (WHS) scaling field method concerning a subjective evaluation of the loudness of synthetic-stationary signals on a category scale and the Stevens thesis of an absolutely coupling between the values of the category scale assessment and subjective sensation, the same for the normal and impaired hearing patients. The NSLE method enables estimation of a hearing threshold taking into account relation between the amplitude changes of the signal in dB [SPL] and a subjective estimation of the signal loudness in a category scale of subjective perceived of loudness. In the next step the IG of the hearing instrument can be calculated. Details of the NSLE method can be found in [3].

Results and discussion

We investigated 51 persons (with high-frequency hearing loss and steeply sloping audiogram, which potentially can have DRs) and only for 4 of them the TEN test gave a positive result. Then, the NSLE test was performed for these patients. The testing signal was a fragment of the h-moll fugue of Jan Sebastian Bach, of 188 seconds duration. Based on results of NSLE test the hearing threshold and the IG were estimated. An example of estimated hearing threshold and the TEN test results (indicating occurrence of the DR above 3 kHz) are shown in Fig. 1a. The hearing threshold estimated from the NSLE is above the threshold obtained from tonal audiometry. The IG predicted by the NSLE was compared to gains predicted by other popular hearing aids fitting methods, Fig.1b. The former gain calculated from the NSLE method was smaller than gains predicted by classic methods.

Subjective assessment of the hearing instrument fitting was checked using the Abbreviated Profile of Hearing Aid

Fig. 1. (a) Hearing threshold from tonal audiometry and NSLE method, TEN test results; (b) Insertion gain predicted by NSLE method and two classic methods; (c) APHAB results – percent of problems for the hearing aid (HA) fitted using NSLE method, HA fitted using NAL-NL1 method and without HA; (d) Benefit for the HA using NSLE method and HA fitted using NAL-NL1 method
Benefit (APHAB) test [4]. The APHAB is a 24-item self-assessment inventory in which patients report the amount of trouble they are having with communication or noises in various everyday situations. Benefit is calculated by comparing the patient's reported difficulty in the unaided condition with their amount of difficulty when using amplification. The APHAB produces scores for 4 subscales: Ease of Communication (EC), Reverberation (RV), Background Noise (BN), and Aversiveness (AV). Results of the APHAB showing percent of problems for 4 subscales are shown in Fig. 1c; benefit from the hearing instrument fitted using NSLE was compared to benefit from classic fitting (NAL-NL1), Fig. 1d. Results of APHAB have clearly shown that fitting based on the NSLE was more beneficial. This observation is not surprising because literature reports postulate significant reduction of the IG in the frequency interval covered by the DR, [5]. Mentioned report was based on vowel-consonant-vowel (VCV) material. Our results confirm the need of the IG reduction for more complex sound material.

Conclusions

- In the case when no significant improvement in speech intelligibility is obtained after hearing aid fitting using a classic method, a detailed cross checking analysis of all available audiology data is postulated.
- When the occurrence of a dead region is possible, the TEN test must be done.
- Presented results of pilotage investigations show that hearing aid fitting for patients with dead regions, based on NSLE procedure, give better subjective assessment when compared to fitting based on other procedures.

References