Interactive Fitting-Wizard in a Home Environment

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Introduction

Wireless TV-headsets help people with mild and moderate hearing loss to enjoy TV and music in satisfying loudness without disturbing their neighbours. Even users of hearing aids suffer from bad speech intelligibility caused by background noise or bad acoustics during watching TV. Headphones offer a solution to bypass the free field influences. The user can choose his individual loudness level at the headset while the speakers of the TV device have their own level. But sensorineural hearing loss is usually combined with an altered loudness perception and a lower range in dynamics. To compensate sensorineural hearing loss it is necessary to adjust individual compressive gains. To give the users of TV-headsets the possibility to adapt not only the volume but also the dynamics of the TV signal, three different versions of interactive self fitting systems were designed and evaluated, particulary with regard to an improvement of speech intelligibility.

Abbildung 1: The Sennheiser Audioport A200 headset was used in this study.

Realisation of three Fitting Versions

The graphical user interfaces (GUI) of the fitting-system are designed to be easily operated. The users are not in the need of audiogram data or any other technical or audiological background. The duration of the fittings should not take more than 10-15 minutes. This restricts the number of fittable parameters. Three versions of fitting-systems for TV-headphones were realised. All fitting procedures are devided in two main blocks, one block of level metering and one block of fine tuning. During the first block LOW- and HIGH-Levels are measured within every compression band. These LOW- and HIGH-Levels are combined with reference values of normal hearing people the basis of computing the compression parameters compression ratio, compression threshold and the linear gains at the compression threshold. To adress also asymmetrical hearing loss the measurements are conducted for both ears seperately. Altogether twelve thresholds are metered, LOW and HIGH-levels in three bands and for both earsides. In the fine tuning block the subjects can correct the stereo balance and change the sound balance with the help of a sound weighting mechanism. During the whole fittings the test signals are taken out of broadcasts television and movies.

The compression plug in is implemented in the signal processing chain upstream of the volume control of the TV device (input controlled compression). The user can change his monitoring loudness without a fewer influence to the dynamics of the signal. The system has been implemented in the HörTech Master Hearing Aid (MHA), a software platform for real time audio signal processing [1]. The used compression algorithm allows independent processing in three compression bands ($f_c = [250, 1000, 3000]$). The attack- and release times are fixed to 5 and 100 ms. An adaptive smoothing filter computes, in each step, the differences between current input to the filter and last output of the filter. Dependent on these differences the filter will nearly not follow small changes in level and will follow larger changes in level immediately, with a smooth transition between the extremes. Every compression band (A = low frequencies, B = middle, C = high) is devided in three equaliser bands with the edge frequencies $f_e = 75, 178, 354, 612, 866, 1225, 1730, 2450, 3460, 4700 Hz$. A limiter makes sure that the headphone level makes no damage to the health of the ear.

Differencies of the Fitting Versions

The LOW- and HIGH-levels of Version 1 are measured with the help of frequency specific sounds of an animation film. The loudness levels are adapted by 6 dB steps. The user is asked to adapt levels which are „low, but audible“ or rather „not uncomfortable, but loud“. After this first block of level metering a second block enables the user to improve sound and panorama setting of the processed audio. The user has to review a processed News magazin and can choose between the attributes „tinny“, „flannely“ and „comfortable“. The system will then prescribe more amplification for the low frequencies (if the judgement has been „tinny“), more amplification for the high frequencies („flanelly“), or not alter the amplification settings achieved so far („comfortable“).

Fitting Version 2 uses band filtered speech of a News magazin as audio stimuli for adjusting the individual LOW and HIGH levels: In a first step LOW- and HIGH-levels are measured with news material filtered in the lowest compression band. To get the LOW- and HIGH-Levels

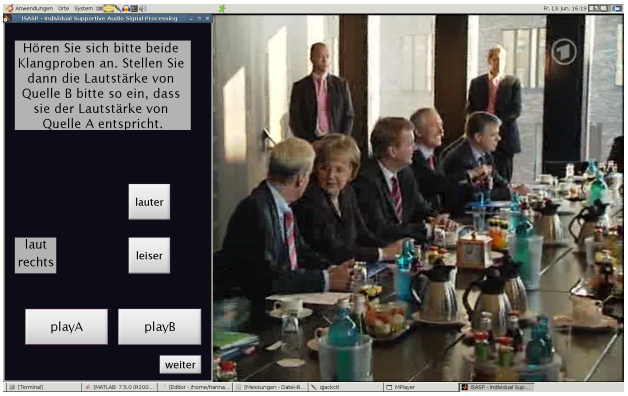

Abbildung 2: GUI of Selffit Version 2&3: „Please listen to the both sources. Then adapt the loudness of the right source B to the loudness of the left source A.“

in the upper compression bands the subjects have to adapt the levels of in the second and third compression band filtered news material to the perceived loudness of the LOW- and HIGH-levels in the lowest compression band. Figure 2 shows the user interface. This procedure was motivated by the Eartuner Fitting, developed by the Danish company Microsound [2].

Version 3 works in principle like Version 2, with a small difference: only the LOW-Levels are measured individually, the HIGH-Levels are fixed in relation to technical maximum. The regulation of the 2nd and 3rd version are stepped by 3 dB.

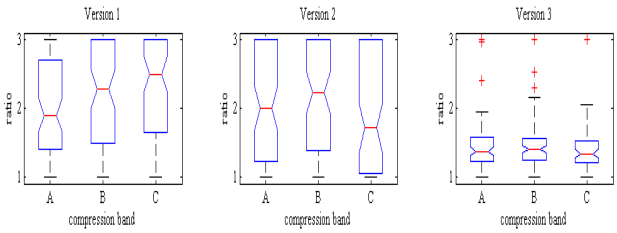

Abbildung 3: Median and interquatiles of the reached compression ratios over 36 hard of hearing subjects for the fitting Versions 1 to 3.

The fine tuning of Version 2&3 works differently than in Version 1 and its stimuli are the sole exception of only realistic broadcast audio - the used TV material was prerecorded by the author. The subjects have to understand a high frequency word and choose the right answer out of a list of four rhyming words with a large contingent of high frequencies like „fish“, „dish“, „wish“ and „kiss“. If the users have choosen the right answer the equaliser settings stay as before, else the high frequencies are amplified and the low frequencies damped by the tone balance mechanism with in maximum 3 dB.

Evaluation

The reference values has been established by measurements with ten normal hearing subjects (aged between 21 and 56 years, median !!!!! years, mean !!!!! years). The three fittings were performed with overall 36 subjects (aged between 15 and 73 years, median 64 years, mean 61.4 years) with mild and moderate hearing loss. Figure 3 shows the averaged compression ratios as a result of the three different approaches. To account the benefit for the hearing impaired the speech reception threshold (SRT, signal-to-noise-ratio which enables 50% speech recognition) of the subjects was measured with the help of the Oldenburger Sentence Test (OLSA) [3]. Two measurements were performed: The first evaluation was arranged with eleven hearing impaired subjects (aged between 54 and 73 years, median 64 years, mean 63.6 years) and the speech reception theshold was measured with OLSA-noise for masking the speech.

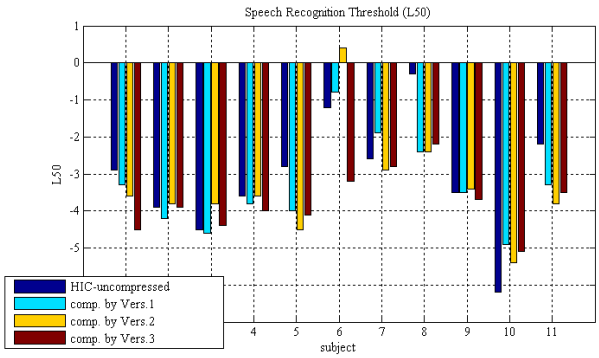

Abbildung 4: SRT of 11 subjects via headphones without (identity) and with compression as a result of diverse fitted compression parameter sets. The SRTs are measured with the help of the Oldenburger Sentencetest performed with OLSA speech noise.

The profit for the eleven subjects, reached by self-fitted compression related to the uncompressed headphone signal, shows a successful fitting: seven of 11 subjects take a profit to speech intelligibility by fitting Version 1, five of 11 subjects take profit by fitting Version 2 and eight of 11 subjects take a profit by fitting Version 3. Four of 11 subjects take a profit of all fitting versions, only one person does not take benefit by any version (Fig. 4).

In a second experiment the OLSA was performed with multi-talker-babble noise (mono) and 25 further subjects with mild and moderate hearing loss (aged between 15 and 73 years, median 64 years, mean 60.5 years). The multi-talker-babble noise sounds more like an realistic conversation of several people in the background (cmp. cocktail party effects).

Fig. 5, again comparing the uncompressed speech with the compressed speech, shows for nearly 50% (12 of 25) of the subjects an improvement of SRT by all fitting versions. 17 of 25 subjects take a profit to speech intelligibility by fitting Version 1, 18 of 25 subjects take profit by fitting Version 2 and 18 of 25 subjects take a profit by fitting Version 3. Three of 25 subjects does not take profit by any fitting version.

Furthermore the influence of compression on sound quality and the exspecting system accceptance of users was prooved by pair comparisons. Diverse TV-formats (like magazin, news, daily, talk or commercials) from different

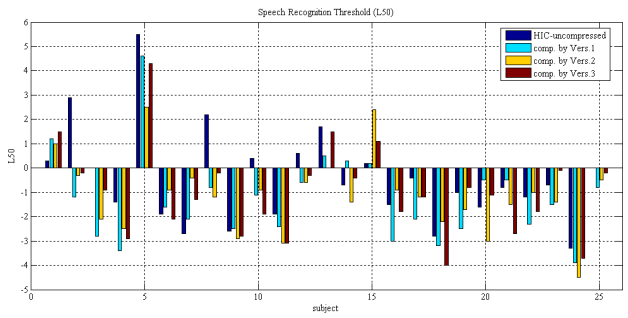

Abbildung 5: SRT of 25 subjects via headphones without (identity) and with compression as a result of diverse fitted compression parameter sets. The SRTs are measured with the help of the Oldenburger Sentencetest performed with multi-talker-babble noise mono.

German broadcast stations (NDR, RTL, ZDF, Kabel1, Pro7) were processed with the different fitted compression parameter sets and compared to original related to speech intelligibility and sound quality. The subjective most comfortable levels of all processing versions were metered during the Fine Tuning block additionally to offer the comparison pairs in a comparable loudness. Both categories were won by Version 3, the original was setted on last order, in the category sound quality together with Version 2(6).

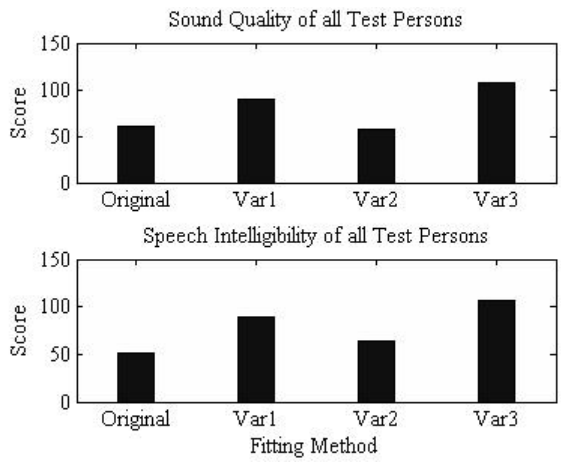

Abbildung 6: Ranking of the paired comparison test with eleven subjects.

The pair comparison evidences that the signal processing of the fitting-system is preferred by most of the subjects compared to the original in the matter of speech intelligibility and sound quality.

Conclusion

In principle self-fitting of a frequency-dependent compressive gainrule are surprisingly feasible via a interactive fitting method. The parameter sets of the different approaches are very different, but the compression settings all work in principle. The self-fitted compression improves the speech recognition thresholds at least for most of the subjects. Also the fundamental goal of fitting headphones with only realtime broadcast material seems to be accessible.

Acknowledgement

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