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INTELLIGIBILITY OF POLISH AND GERMAN SPEECH FOR THE POLISH AUDIENCE IN THE PRESENCE OF NOISE

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The ability of Polish listeners to understand Polish in the presence of two different noises, the Fastl noise and CCITT Rec. 227 noise was measured. The Speech Perception in Noise SPIN test was administered at 68 dB SPL to 10 normal listeners. The results are compared with those of similar experiments done for German. In the case of CCITT noise, most of the listeners have more difficulty to understand both Polish and German.

1. Introduction

The development of the hearing aids technique and new procedures of their fitting as well as the progress in acoustics and sound perception, have opened new opportunities in the field of aiding the hearing impaired people.

The hearing aids based on analog-digital converters can operate at a selection of programs, in many frequency bands, employing several regulating modules with variable parameters. Many of the technical features of these instruments have not been exploited yet due to the lack of knowledge about the nature of the hearing processes, particularly under pathological conditions and when the intelligibility of signal information is affected by noise [1, 8, 9, 10].

The results of tests of hearing aids conducted according to the recommendations of the standards IEC 118 or DIN 45605 differ from those of appraisal of the same devices in clinical tests [15, 17]. The necessity of applying natural signals while fitting a hearing aid arises from the attempts at simultaneous testing of most psychoacoustic characteristics of hearing which determine the quality of perception [15, 28]. Research focusing on allowing an optimal acoustic comfort for hearing-impaired people showed that the most stable attributes appeared to be the *sharpness* and *loudness* of a sound [11].

Basing on the *loudness* attribute with reference to natural sounds of time-variable amplitude, a new method (HGJ-standing for Hojan, Geers and Jezierska) is proposed for fitting hearing aids [13, 14].

The hearing aid chosen and subsequently fitted to the hearing impaired person will be accepted only when it satisfies the condition of a better intelligibility of speech [18].

Tests containing lists of monosyllabic words are used for this purpose [2, 3, 19, 20]. For the German language these lists are compiled into the so called Freiburger-Wörtertest [27], for Polish they are newly created by PRUSZEWICZ and DEMENKO [22, 23, 24].

Next, intelligibility of speech requires the hearing to be characterized by correct properties, particularly with regard to the following features:

a. temporal resolution
b. frequency resolution
c. frequency discrimination
d. intensity discrimination.

The effectiveness of all, or only some, of those properties are degraded among hearing impaired persons when compared to normally hearing people. The former frequently complain, for example, about environmental acoustic noise interfering with their listening to a speech [7, 28].

In many instances, a hearing aid optimally selected an fitted under laboratory conditions (isolated room) ceases to work satisfactorily when used in a loud acoustic environment, and its usage is frequently discontinued by the person with hearing problems. In a loud acoustic environment, people hearing normally can manage to concentrat on a unique speech signal and perceive it correctly [7, 17]. Very frequently, this skill vanishes with the heairng impaired people.

There is a common understanding of the need to design new procedures to be used in fitting the hearing aids, procedures based on natural sounds, under the conditions of an acoustic environment. First attempts towards the solution of this problem have been reported [12, 16, 25].

2. Masking noise

With the aim of examination hearing impaired people under condition of acoustic disturbances, FASTL [5, 6] has proposed to use the noise characterized in Fig. 1.

The spectrum and time evolution of this noise resembles the spectrum and time evolution of a speech signal representing fluent speech of many nationalities [26]. Parameters of this noise with regard to the form of its time envelope (with the same spectrum) differ from the parameters of noise employed in audiology according to CCITT Rec. G 227 specifications [5].

Fastl's noise was weated by modulating CCITT noise by a bandpass noise centered at 4-Hz. The disturbing noise proposed by Fastl allows among others, to

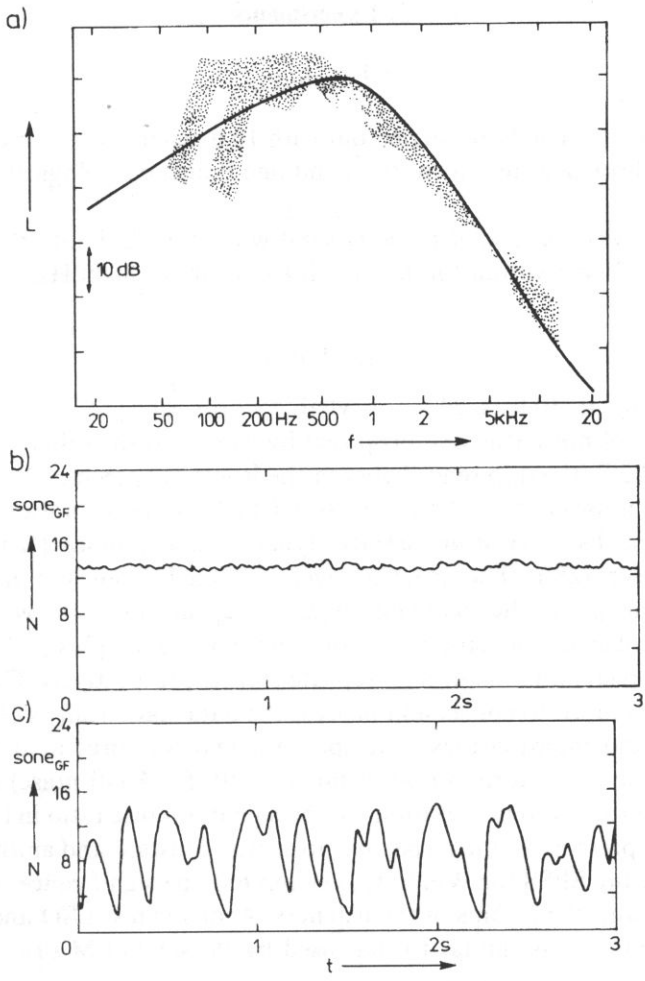

Fig. 1. Envelope in frequency a) and time domain of the CCITT Rec. G 227 noise b) and Fastl's noise c); From [6, 12].

simulate the effects like competing speech or cocktail party and helps to indicate the reduction of the effectiveness of the hearing properties listed above under **a**. through **d** in hearing impaired people.

In the present study, the intelligibility of Polish speech by a sample audience, made up of 10 Polish listeners of normal hearing and one Polish pathological listener, is investigated under the condition of Fastl's noise and next under that of CCITT Rec. G 227 noise. Next, the data for normal hearing people are compared with the results of intelligibility of the German speech by Polish and German listeners [12, 16, 25], in order to get information on the feasibility of the international normalization of this noise.

3. Experiments

3.1. Subjects

The experiments have been carried out with 10 listeners of Polish nationality aged from 36 to 55 whose hearing was normal and one Polish pathological listener aged 65 years.

The hearing was considered to be normal when the audibility threshold did not drop more than 20 dB within the bandwith from 100 to 8000 Hz.

3.2. Methods

The speech signal (10 lists, 24 monosyllabic words each [22, 23] in presence of one of the two kinds of noise (the one proposed by Fastl and the other one according to CCITT Re. G. 227), the difference between the levels of speech and noise being -18 to 0 dB (Fastl's noise) and -11 to $+3$ dB (CCITT Re, G227 noise), was applied to both ears of the listeners using electro-dynamic headphones (Beyer DT48 with freefield equalizer [28]). The listeners were isolated from the natural acoustic environment in a cabin. They were instructed to repeat loudly the words they heard. The instructor collected the data into a computer coding the plus (+) and minus (−) signs for the correctly and incorrectly repeated words, respectively. Custom designed software was employed to collect and process the data statistically yielding the values of the median and interquartiles. The speech signal was presented to the listeners using the successive lists form amongst no. 1 to 10 (for Fastl noise) and 1 to 8 (for CCITT noise) at the random variations of the signal to noise ratio in (2 dB steps); the level of acoustic pressure of the respective noise was constant and amounted to 68 dB. Subsequently, using SPSS for Windows, version 6.0, the significance of differences at 0.05 was tested with the groups of the listeners. Acoustic test LSD and Duncan were used. The procedure was similar to that used by PLOMP and MIMPEN [21].

4. Results

The results of the study of 10 listeners of Polish nationality, representing normal hearing, is presented in Fig. 2.

The circles in Fig. 2 refer to the first experimental data concerning the intelligibility of the Polish speech in the presence of Fastl's noise averaged over 10 listener sets whereas the squares refer to the noise pattern as specified by CCITT Rec. G. 227.

The medians for 50% of the data read as follows:

— in the presence of Fastl's noise, $\Delta L = -8.0$ dB

— in the presence of CCITT noise, $\Delta L = -5.0$ dB.

In Fig. 3 the results of the same experiment carried out with a Polish pathological listener are displayed, (circles — Fastl noise, squares — CCITT noise).

The medians for 50% of the date are as follows:

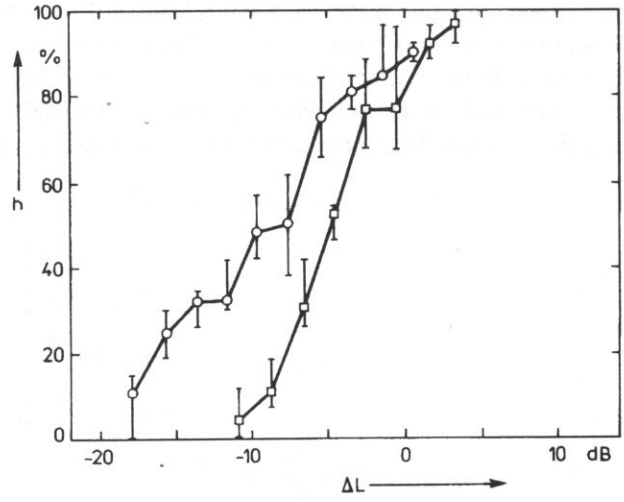

Fig. 2. Scores h for the monosyllables as a function of speech to noise ratio for 10 normal hearing Polish listeners in the presence of: — Fastl's noise circles, — CCITT noise squares.

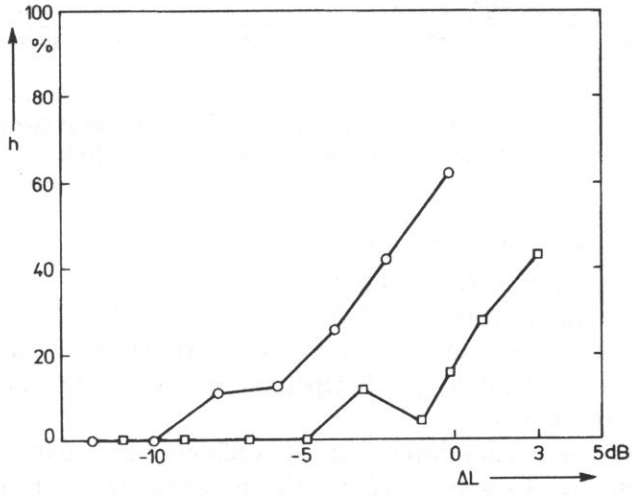

Fig. 3. Scores h for the monosyllables as a function of speech to noise ratio for pathology: — Fastl's noise circles, — CCITT noise squares.

— in the presence of Fastl's noise

$$\Delta L = -1.2 \text{ dB}$$

— in the presence of CCITT noise

$$\Delta L > +3.0 \text{ dB}.$$

With the aim of evaluating the effect of Fastl's noise on the process of speech perception and intelligibility in a more general sense, the results of a similar study are shown in Fig. 4, where both German (circles) and Polish (squares) speaking populations (normal hearing), were subjected to the monosyllabic tests built of German words only (Freiburger Wortertest, the words lists no. 1–17).

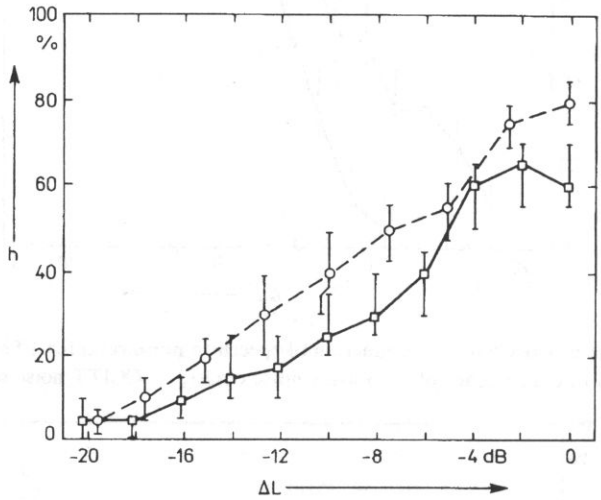

Fig. 4. Scores h for the monosyllables as a function of speech to noise ratio for 88 German subjects (circles — see [12]) and 40 Polish subjects (squares — see [16]).

The corresponding medians for 50% are:
— for Polish listeners $\Delta L = -4.0$ dB
— for German listeners $\Delta L = -7.5$ dB.

This result is in accord with the previous reports [1, 8, 9] and points to the differences in the intelligibility of speech depending on whether the speech is produced in one's mother tongue or not.

The statistically significant differences (at confidence level 0.05) relevant for the plotted data from Fig. 4 occur at $\Delta L \geqslant -10$ dB; when $\Delta L < -10$ dB all the data coincide within the statistical error.

5. Conclusions

1. The intelligibility of both the native and foreign speech is better in the presence of the Fastl's noise than in that of CCITT Rec. G. 227 noise.

2. Fastl's noise allows a better differentiation between the intelligibility of normal and pathological cases than the CCITT Rec. G. 227 noise does.

3. Similar medians of 50% of the intelligibility of the Polish speech by Polish listeners and the German one by German listeners, both affected by noise as designed

and specified by Fastl), evidence the equivalence of these two word tests: the Polish one and the German one.

4. The results indicate the universal character of Fastl's modulated noise normalized with respect to a multilingual speech.

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