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The Sentence Intelligibility in Different Types of Noise Regarding People with a Normal Hearing Ability

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Abstract: The capability of speech understanding can be tested in the form of sentences. This report describes the origin of a new test in the Czech language to evaluate the sentence intelligibility with the presence of the competitive disturb noise. The results of the test depend on the test project, sentence material, competitive signal, test evaluation, and hearing conditions. Pilot results were obtained from 3 different noises (Speech noise, Babble noise, Cocktail party noise) at 16 people with a normal hearing ability. The Speech noise, which is recommended by a technical standard, mask sentences very poorly. On the other hand, the Babble noise and the Cocktail party noise, which are used to mask sentences in different languages, mask at lower intensities.

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Introduction

The use of speech signals for classification of hearing disorders is older than 200 years. Up to the present approximately 100 tests have been published, which bear their title either according to the author of the test or the place of the origin of the test [1]. In the Czech language the "Czech Speech Audiometry" was published in 1960 by Seeman [2]. Testing the speech understanding can also be implemented with presenting the testing material in the form of sentences at the presence of a disturb signal. This issue has been treated with a lot of interest abroad, however, in the Czech language these audiological tests have not been compiled and used so far. This report shows the results of the influence of different types of noise on the sentence intelligibility at persons with normal hearing ability.

Tests for examination of the sentence intelligibility have no international standards, and so the normative data must be determined on the basis of the individually prepared material [3]. The results are influenced by several factors:

1) The used sentence material (sentences with high probability of the presence of certain words compared to the sentences with low probability of this presence), number of words in the sentence.
2) The type and characteristics of the used competitive signal: e.g. the Speech noise, which is defined by a technical standard; the Babble noise, which originates from the mixture of speeches of several people; the Cocktail Party Noise is a randomly obtained noise at a social event. Sometimes the "Babble noise" is created from the speaker's speech. Some foreign tests use settled technical noises – white noise, pink noise.
3) The voice and the speech of the professional speaker (voice pitch in the conversation, frequency spectrum (male vs. female), accuracy in pronunciation, speed of the spoken speech).
4) The relationship between parameters of the speaker's voice and parameters of the used competitive disturb signal, the similarity or diversity of frequencies and time responses of the signals.
5) The way of evaluating the tests – the way of attaching the points for a correctly or partially repeated part of sentence (1 key word, which has a high probability of determination based on the sentence context; a higher number of evaluated words in the sentence; percentage of the number of the repeated words, etc.)
6) Listening in the so called free field in the audiometric booth or listening using headphones.

Literature brings many other possibilities and variations as regards the implementation of the sentence tests in practice [4]. For example a different signal level, on which the sentence test is presented; the competitive disturb signal is applied only at the presence of a sentence or is presented without interrupting and continuously; the noise intensity or the sentence material intensity are changed and

the other signal has a constant level. All these factors influence the results of the testing.

Material and Methods

The tested material used for this work in the Czech language included 10 decades of sentences. These sentences are from 4 up to 10 words long. The material was read by a professional speaker and recorded digitally in studio conditions. The length of sentences was from 1.6 s up to 3.5 s. The pause between the sentences was set up for 6.5 s. The average intensity of all the decades of sentences was regulated for the same level in accordance with EN ISO 8253-3:1998. This standard allows the maximum deviation in the sentence intensity of ± 3 dB from the average of sentences in a decade. In our case we shrank this intensive interval to ± 2 dB. Other authors of tests (e.g. [5]) balanced the intensities of the separate sentences in such a way that all the sentences have the same root-mean-square value (RMS). It is necessary to mention that the root-mean-square value (RMS) is not related to the fact of how the sentence is intelligible, because it observes only the energetic point of view and takes no account of the sentence contents, neither expresses the "correct" value, how the intensity of sentences should be balanced and set up. In our case all the average intensities of the sentence decades have the same average RMS value.

The set-up of the levels was chosen in such a way to keep the same calibration of the examined audiometric chain with the today's used digital version of the "Czech Speech Audiometry" compiled under the direction of MUDr. Zdeňek Hložek at the ORL Department at the Palacky University in Olomouc [6].

As the competitive signals these signals were chosen:

a) The Speech noise – defined by the technical standard EN 60645-2:1993 – Paragraph 13.1.
b) The Babble noise, which consists of independent speeches of 8 speakers, created at the Phoniatric Department. This noise contains recordings of 4 men and 4 women, who read the text. The beginnings of the read text were moved in the mixture, so each one started at a different moment. If there was a situation that the final speech mixture contained an apparent and certain indication of a word, this passage was cut off from the recording in order not to confuse listeners. Different authors of tests usually use the combination of 6 to 12 speakers, and according to the empiricism it was found out that the combination of 8 persons mask most expressively [7].
c) The Cocktail party noise – a recording taken from a CD from the Czech Speech Audiometry.

All the competitive disturb signals were set up for the same average level of sound like the average level of sound of all the sentences. The listening to the material

was implemented in the audiometric booth in the free field from loudspeakers 1 m in front of the listeners with the azimuth of 0 degrees.

The characteristics of the disturb signals are different both in the field of frequency and time. These diversities show us even the different masking of the speech signal. The Speech noise has stable characteristics, both concerning the composition of frequency and time. The difference between the maximum and the minimum of the intensity is 1 dB (time constant 100 ms). The time and spectrum characteristics of the Babble noise are similar to the human speech; the intensity fluctuation is between the maximum and the minimum level of 6 dB. The characteristics of the Cocktail party noise are situated between the Speech noise and the Babble noise, the intensity fluctuation is around 4 dB.

The evaluation of the sentence intelligibility with all three types of noise was implemented with 16 people with normal hearing ability (the tone audiogram of 0.5–6 kHz better than 20 dB HL (hearing level), age of 30–55 years). Intervals between separate tests were 2 weeks. The first examination was implemented with the Speech noise, the other one with the Babble noise and the third one with the Cocktail party noise.

The sentences were presented with the level of 60 dB SPL (SPL – Sound Pressure Level). This intensity was chosen because already at the first testing measurements it was found out that the Speech noise masks more expressively at higher intensities, which the listeners find annoying and unpleasant. As regards various sentences, the level of the disturb signal was presented on the following sound levels: With the Speech noise 70–75–80 dB SPL, with the other two types of noise, which masked more already at lower levels, the level was 65–68–70–72–75 dB SPL. The sequence of the intensities of the competitive noise was selected randomly, but in such a way that for each intensity there were at least 2 decades of sentences to be examined. The evaluation of the sentence intelligibility: Correct repetition of the sentence – 1 point (10%), 1 confusion or mistake in the sentence ½ point (5%), with a bigger deviation – 0 points. This system of evaluation, as it was mentioned in the introduction, is not the only possible one. There are several other methods.

Results

The results showed that the training effect, arising with the use of the same probands and 3 different noises, is not substantial. The chosen sequence of the noises was selected suitably – the sequence was "Speech noise, Babble noise, Cocktail party noise". In this sequence the sentence intelligibility was gradually going down and was not increasing, so there was no influence of the training. The reason of this was probably the 14 days interval between the tests and the higher number of sentences (100), which the listeners often did not understand completely because of the masking noises.

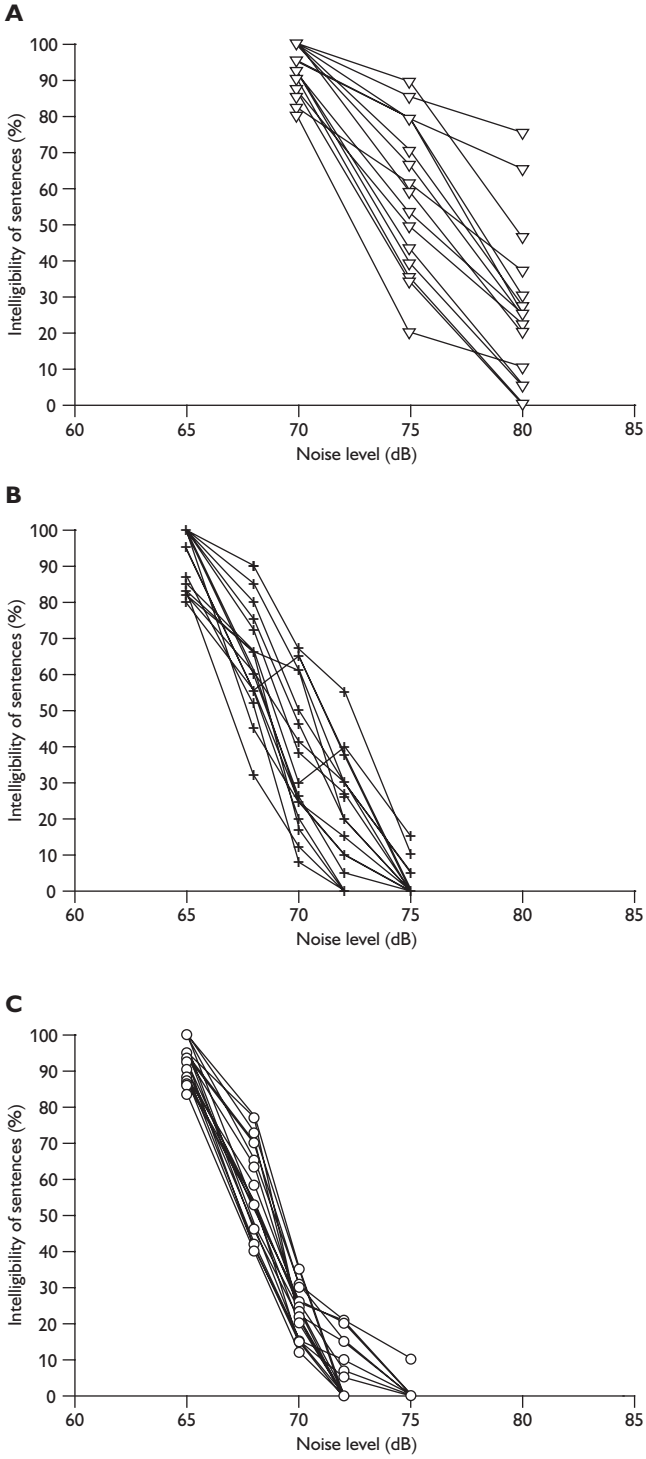

Figure 1 – The detail sentence intelligibility at listeners with a normal hearing and different levels of 3 concurrence noises: a) Speech noise, b) Babble noise, c) Cocktail party noise

The Speech noise is typical for its low grade of masking. Many listeners said that the noise intensity of 80 dB SPL was already unpleasant and deafening. With the use of this maximum masking level the listeners had a big span in the results regarding the sentence intelligibility. The question is, whether this span of results is not influenced by the unpleasantness of the noise they listen to (Figure 1a).

The other two competitive signals mask at lower intensities. The span between the 100% sentence intelligibility and the 0% sentence intelligibility with different listeners means the change in the noise intensity with 10 dB up to 15 dB. In Figure 1b there are apparent unexpected jumps in the Babble noise, concerning the sentence intelligibility of 2 listeners, which is caused by the inaccuracy of the psychoacoustic measuring. 20 sentences in the examination seem to be insufficient

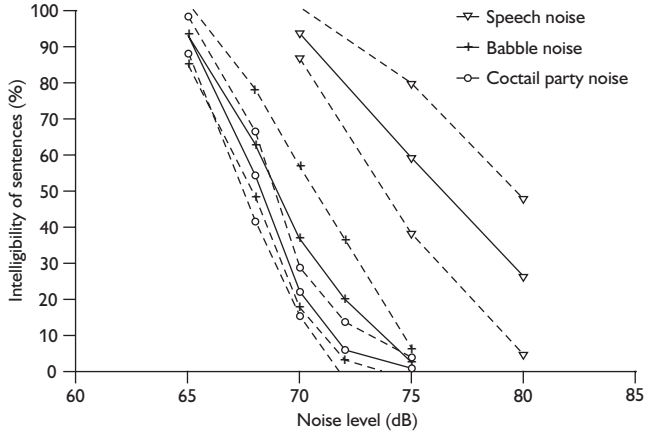

Figure 2 – The comparison of the effect of all 3 competitive signals. The full line connects the average values of the group of listeners, the dotted line the values of 1 standard deviation.

Table 1 – The sentence intelligibility of the group of listeners in dependence on the level of the Speech noise (average value +/- standard deviation (%))

	Sound pressure level of noise signal (dB SPL)		
Noise type	70 dB	75 dB	80 dB
Speech noise	93±7%	58±21%	58±21%

Table 2 – The sentence intelligibility in the presence of the Babble noise and the Cocktail party noise

Sound pressure level of noise signal (dB SPL)					
Noise type	65 dB	68 dB	70 dB	72 dB	75 dB
Babble noise	93±8%	63±15%	37±19%	20±17%	2±4%
Cocktail party noise	93±5%	54±12%	22±7%	6±8%	1±3%

to obtain more fluent processes (Figure 1b and 1c). The comparison of the effect of all 3 competitive signals is shown in Figure 2. The full line connects the average values of the group of listeners, the dotted line the values of 1 standard deviation. In our test the Cocktail party noise masked even a bit more expressively than the Babble noise. The results of the sentence intelligibility of the group of listeners in dependence on the level of the disturb signal are shown using numbers in Tables 1 and 2. The average value of the 50% sentence intelligibility, while presenting the sentences with the intensity of 60 dB, was 68 dB with the Cocktail party noise, 69 dB with the Babble noise and 76 dB with the Speech noise.

Conclusion

The Speech noise is typical for its low masking grade. The other two competitive signals mask at lower intensities, while abroad the Babble noise is used for its significant interference with the speech signal in the time and spectrum domain. The time characteristics of the Babble noise are similar to the human voice and therefore it masks more expressively on the central level than the random stable noises (speech noise, pink noise, white noise,...). However, the Cocktail party noise is not clearly and technically definable (the randomly recorded noise at a social event), even its characteristics change during the time – speech, laughter, clinking of glasses or plates. Therefore, nowadays, our next research regarding the field of masking sentences with a competitive signal focuses on the Babble noise, which is also used in the foreign audiological tests.

References

1. BOSMAN A.: Review of speech audiometric tests. In: Moderne Verfahren der Sprachaudiometrie. Kollmeier B. (ed), Median-Verlag von Killisch-Horn GmbH, Heidelberg, 1992, 11–34.
2. SEEMAN M.: Česká slovní audiometrie (in Czech). Státní zdravotnické nakladatelství, Prague, 1960.
3. MENDEL L. L., DANHAUER J. L.: Audiologic evaluation and management and speech perception assessment. Singular Publishing Group, San Diego, London, 1997.
4. WAGENER K. C., BRAND T.: Sentence intelligibility in noise for listeners with normal hearing and hearing impairment: Influence of measurement procedure and masking parameters. *Int. J. Audiol.* 44: 144–156, 2005.
5. NILSSON M. J., MCCAW V. M., SOLI S.: Minimum speech test battery for adult cochlear implant users: User Manual. House Ear Institute, Los Angeles, 1996.
6. HLOŽEK Z.: Czech speech audiometry – CD recordings. Palacký University Olomouc, Department of Otorhinolaryngology, Olomouc, 1994.
7. FREYMAN R. L., BALAKRISHNAN U., HELFER K. S.: Effect of number of masking talkers and auditory priming on informational masking in speech recognition. *J. Acoust. Soc. Am.* 115: 2246–2256, 2004.