EuroRegio2016
June 13-15, 2016
Porto Portugal

IMPACT OF ACOUSTIC CONDITIONS IN CLASSROOM ON LEARNING OF FOREIGN LANGUAGE PRONUNCIATION

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Abstract
Teaching a foreign language to pupils and students has been always a challenging task. In comparison with other lessons, such as geography, history or mathematics, which are typically given in the mother tongue, learning of a foreign language requires a more than a moderate speech intelligibility. For learning of the proper pronunciation of a foreign language, a noise and reverberation free environment is definitely preferred but challenging to realize from the architectural point of view. Acoustic problems are sometimes tackled by special electroacoustic equipment such as headphones or even special rooms with special cabins. This, however, makes pupils listen in a non-natural way and might bring up challenges of psychological nature, due to the insulated nature of the listening conditions. In this article we show a pilot approach on how to investigate the issues related to improvements in natural listening conditions achieved by the acoustic design of a classroom.

Keywords: acoustics, classroom acoustics, speech intelligibility, speech recognition

PACS no. 43.55.Hy, 43.55.Br

1 Introduction

Learning of a foreign language at school needs in comparison with other types of courses (such as mathematics, physics, history or art) that are taught in mother tongue more than a moderate speech intelligibility [1, 2]. This is because the process of learning of the proper pronunciation requires quiet and dry acoustic conditions [3, 4, 5]. In some language schools teaching process is supported by electroacoustic systems that consist of headphones and microphones. In most of the primary and secondary schools teaching of foreign language is performed in ordinary classrooms, which opens challenges for architects and interior designers [6, 7]. In this article we compare speech intelligibility expressed by objective acoustical numbers (such as speech transmission index – STI) [8] with spectrograms of chosen vowels in the Slovak language. The chosen vowels A-E-I-O-U are analyzed under different acoustic conditions in terms of their reverberation time without background noise.

Human speech consists of vowels and consonants, where vowels carry most of the acoustic energy, and consonants contain most of the "speech information". Acoustically speaking, most of the consonants contain frequency components above 1 kHz and vowels carry most of the information in lower tones. The amount and structure of vowels and consonants also depends on the language. Some languages contain lots of vowels and might therefore sounds louder than others may.

2 Case study

2.1 Description of the case study

Two different virtual acoustic scenario were chosen for the experiment as a boundary conditions. Both of them were shoebox-shaped classrooms with dimensions of 6,1 x 11,8 x 3,5 m, volume of 252 m^3 and area of interior surfaces 329 m^2 (Fig. 1). The first variant A was a classroom with optimal acoustic conditions in terms of speech intelligibility prescribed in recent guidelines. The second variant B is the same classroom without acoustical treatment resulting in long reverberation time and consequently bad speech intelligibility. In both acoustic scenarios one position of a sound source (teacher) and two positions of a receiver (students or pupils) were chosen. The receiver No.1 was considered in a front row approximately 2 m from the teacher and the other one in a back row at a distance of 8 m. The 3D model and reverberation time values for the two variants are shown in the Figure 1.

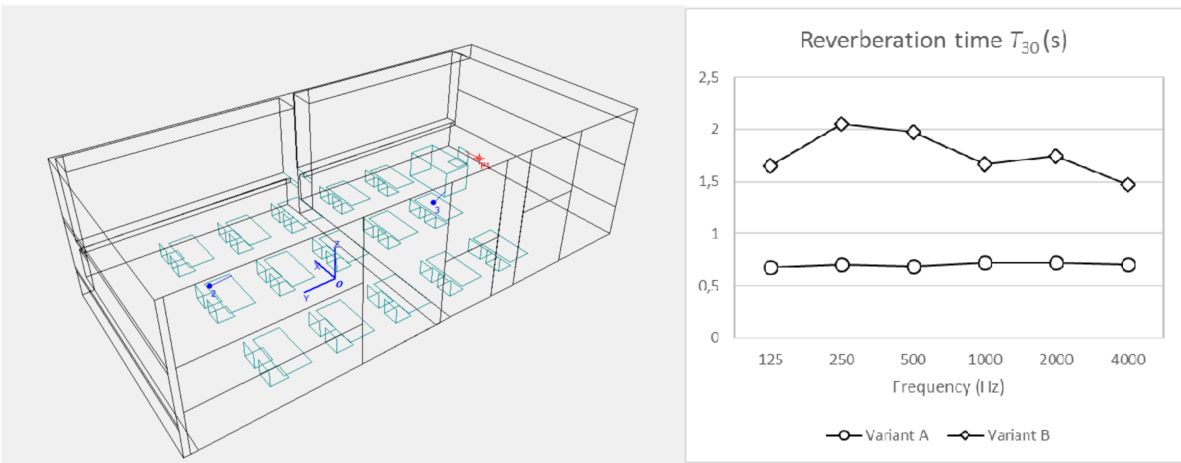

Figure 1 – Virtual model of classroom used for simulations. Two different reverberation time values T_{30} were used.

2.2 Recordings of speech

Anechoic recordings of Slovak vowels A-E-I-O-U were performed by female and male professional language lecturers. They were recorded in 3 different vocal output levels – normal, raised and shout. Spectrograms of the 3 cases are shown in the Figure 2. The top row represents man's voice and the bottom row represents a woman's voice. Spectrograms on the left are recorded in normal output level, the middle picture shows the situation with the raised output and the picture on the right shows result for a shouting person.

The frequency spectra of 5 chosen vowels are rather different. Differences are obvious also between a male and female voice. Letter “A” has most of the frequency content in frequency band from 500 Hz to 2000 Hz with the strongest sounds around 1000 Hz. “E” has the same spread (e.g. 500 Hz and 2000 Hz), but there is rather a different distribution of dominant frequencies. The vowel “I” is typical with fewest sound around frequency 1000 Hz. Looking at the “O” we can see similarities to “E” but the strong frequency band is shifted more towards lower frequencies between 500 Hz and 1 kHz. In case of “U” the major frequency content is shifted even more into the low frequencies with almost no content above 1000 Hz for both male and female voice.

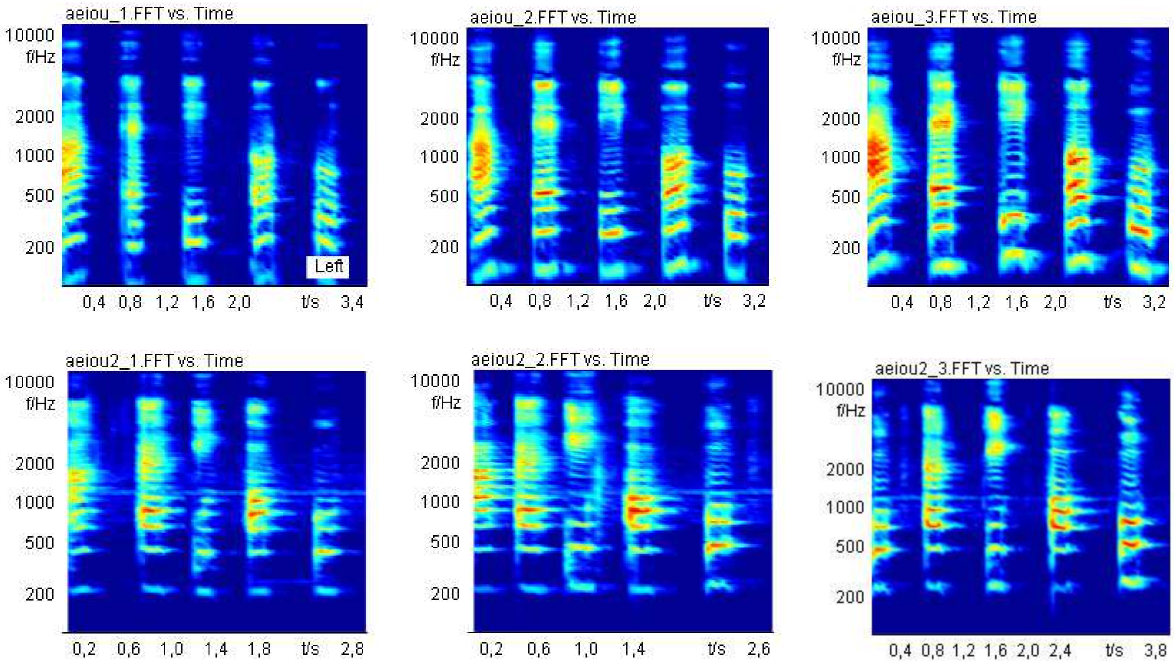

Figure 2 – Spectrograms of anechoic recordings used for auralization (top row – male voice, bottom row – female voice) in 3 different vocal output levels (normal – left, raised – middle, shout – right).

2.3 Simulations

Simulations were performed in Odeon software, which uses a hybrid calculation algorithm based on two calculation methods. For calculation of early reflections, the image source method is used while for later reflections, the ray-tracing algorithm.

Two kinds of data were considered: (1) Objective Speech transmission index (STI) values on one hand and (2) spectrograms of vowels under the given conditions on the other hand. Spectrograms were based on convolution of room impulse responses as taken from simulations with the anechoic recordings mentioned above.

Speech intelligibility in the acoustically treated classroom (variant A) was 0.73 in the frontal position and 0.69 in the back row position. The room with long reverberation – Variant B – has STI value 0.52 in the position of a listener closer to the teacher STI = 0.48 in the back of the classroom, which will definitely lead to worse understanding of speech.

3 Results and discussions

In the spectrograms (Fig.3) we can see to what extent different acoustic conditions influence the frequency spectrum and the decay of vowels.

Figure 3 shows two spectrograms. Both of them represent auralized recordings of a man in a classroom with long reverberation time (variant B). The one on the top is at the position close to the teacher and the bottom is at the back position of the classroom. We can see that influenced by poor speech intelligibility in both cases vowels “E” and “I” start to have similar frequency spectrum, which can lead to a weak intelligibility of pronunciation and therefore confusion during the educational process.

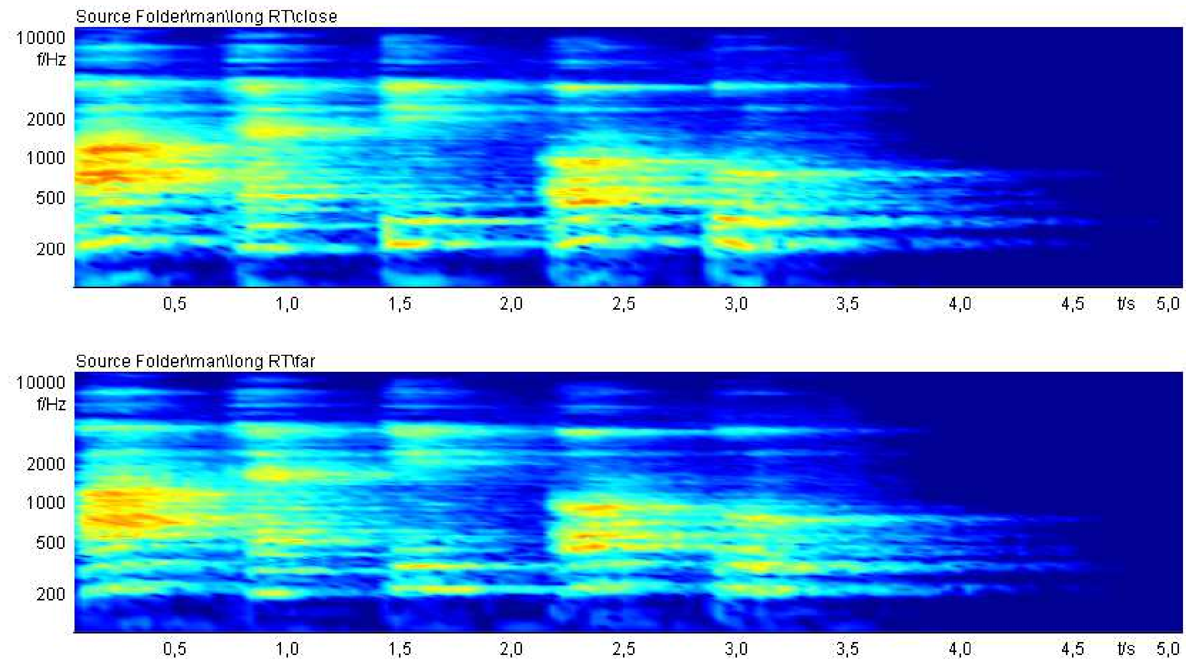

Figure 3 – Spectrograms of convolved anechoic recordings as they were taken from simulations – man’s voice in a classroom with long reverberation time at the position close (top) and far (bottom) from the virtual teacher.

The figure 4 shows that looking at the spectrograms of woman’s voice simulated in classroom with long reverberation time (variant B) we can see there is a difference in comparison with man’s voice. Because of poor acoustical properties of the untreated room, vowels “E” and “O” have a similar frequency spectrum in the case of position close to the lecturer.

These and other observations must be still confirmed by listening tests in the future.

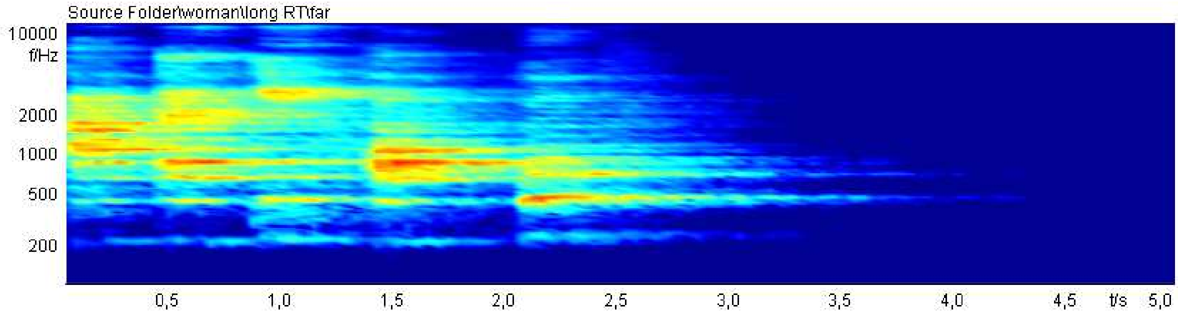

Figure 4 – Spectrograms of female voice in a classroom with long reverberation time at the position of 2 m from the virtual teacher

Acknowledgements

This article was supported by VEGA no. 1/0286/15.

References

[1] Rosenberg GG. (2010) Classroom Acoustics. In Seminars in Hearing 31(3), 188–202.

[2] Vargová A., Pavceková M. Noise Perception in Residential Building Environment. In Advanced Materials Research 649: enviBUILD Buildings and environment. International conference. Brno, 281-284.

[3] Klatte M., Lachmann T., Meis M. Effects of noise and reverberation on speech perception and listening comprehension of children and adults in a classroom-like setting. In Noise&Health. 2010;12(49):270-82.

[4] Zannin P.H.T., Zwirtes D.P.Z. Evaluation of the acoustic performance of classrooms in public schools. In Applied Acoustics. 2009;70:626-35.

[5] Rabelo A.T., Santos J.N., Oliveira R.C., Magalhães Mde C. Effect of classroom acoustics on the speech intelligibility of students. In CoDAS 2014;26(5):360-6

[6] Petrášová B. et al. Challenges in teaching of foreign language pronunciation in nowadays classrooms. In Akustika No.25, Czech Republic, ISSN 1801-9064

[7] Zelem L., Urbán D., Chmelík V., Rychtáriková M. (2015): Analysis of the Acoustic Conditions in the Student Restaurant, In proc of Euronoise 2015 31 May – 3rd June, 2015, Maastricht, The Netherlands, ISBN: 2226-5147

[8] Urbán D., Chmelík V., Tomašovič P., Rychtáriková M. (2015): Analysis of the Acoustic Conditions in a Tent Structures, 6th International Building Physics Conference, IBPC 2015, Energy Procedia XX (2015) XX–XX, ISSN: 1876-6102