Annals of DAAAM for 2012 & Proceedings of the 23rd International DAAAM Symposium, Volume 23, No.1, ISSN 2304-1382
ISBN 978-3-901509-91-9, CDROM version, Ed. B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2012
Make Harmony between Technology and Nature, and Your Mind will Fly Free as a Bird
Annals & Proceedings of DAAAM International 2012

THE SOFTWARE PREDICTION OF PSYCHOACOUSTICS PARAMETERS

BADIDA, M[iroslav]; DZOGANOVA, Z[denka] & SELECKA, L[enka]

Abstract: *Sound is an alternative name for acoustic wave which is possible to make the human sensation. This article deals with noise which is every annoying, harassing, annoying, undesirable, inappropriate or harmful sound. Noise is also defined as an audible sound which either disturbs the silence or an intentional sound listening or leads to annoyance. In this article is described some psychoacoustics parameters and also the superposition of sound by two experiments.*
Keywords: *noise, psychoacoustics parameters, superposition of sound, loudness, sharpness*

1. INTRODUCTION

The sound is in every part of the world. Sound influences greatly the quality of life, since apart from the omnipresence of sound the human ear cannot be easily switched off in order to avoid acoustic input. Although sound can be analyzed and measured in physical terms and numbers, the complete analysis of sound depends on the psychoacoustic attributes of human hearing. [10]

Perception of the everyday world is an exceedingly complicated phenomenon nevertheless our everyday experience may suggest that perception is simple and automatic. [1]

The evaluation of noise depends on the physical characteristics of the sound event, on the psychoacoustical features of the human ear as well as on the psychological aspects of people. [1]

The subjectively perceived noise quality depends on the A-weighted sound pressure level (SPL) and also on other psychoacoustical parameters such as loudness, roughness, sharpness, etc. The known methods for the prediction of the spatial A-weighted SPL distribution in dependence on the propagation are not suitable to predict psychoacoustic parameters in an adequate way. [1]

An assignment of noise can only be retraced with the help of a multidimensional approach which takes into consideration the physical aspects of the sound, the frequency composition, psychoacoustic parameters (loudness, sharpness, roughness, fluctuation strength) as well as the attitude of the listener, the informative character of the sound, and the cultural background. Noisiness and annoyance are more (than energy of sound) sensitive to subjectivity thus the social and cultural backgrounds have important influence on the subjective attitudes of people to the noise. This means that the evaluation of noise depends on the physical characteristics of the sound event, on the psycho-acoustical features of the human ear as well as on the psychological and social aspects of human being [10].

The noise-mapping introduces an approach to predict noise contribution at different places and also to ascertain the standard of accommodation with regard to the environmental noise situation. The noise-mapping based on A-weighted sound pressure level considers the multidimensionality of perception and evaluation mentioned above. In fact, it depends on the spectrum's structure and on the pattern in time domain. Thus, changes of the short time spectrum with respect to the frequency and time domain have an influence on the sound classification. Therefore, the application of psychoacoustics in the context of noise- mapping is inevitable. But, noise- mapping with respect to psychoacoustics parameters is unknown and undeveloped so far [5].

2. PSYCHOACOUSTICS PARAMETERS

Many types of sound influencing human hearing are defined as the sound with periodic or other time course. There are known the two kinds of composit audio: the harmonic sound – is the sound which frequencies of partial sinusoidal components are the integral multiple of fundamental frequency; the noise – it can be random stacionary unperiodical sound or annoying, harrasing unwanted harmfull sound. [11]
Psychoacoustics parameters are the parameters which couse at human psyche. To these parameters belongs:

- Sound level [mel] – it is human sensation parameter able to organize the tones from deep to high.
- Volume [son] – it is human sensation parameter able to organize the tones from quiet to loud.
- Subjective duration [dura] – it is human sensation ability to perceive the temporal duration of sound or space between sounds.
- Roughness [asper] – it is the parameter characterizing the sensation.
- Sharpness [acum] – it is the dimension of timbre.
- Tonality – it is the quantity parameter of perceived ratio of tone and noise quality sound.
- Power fluctuation [vacil] – it is the parameter which characterizes the sensation when temporal changes in amplitude of pure tone are so slow that human hearing is able to monitor it.
- Timbre – it is the ability of human sensation able to differentiate two nonidentical sounds with common volume and sound level.
- Sensory friendliness – it is the combinated parameter of roughness, sharpness, tonality and volume. [2]

Loudness belongs to the category of intensity sensations. The stimulussensation relation cannot be constructed from the just-noticeable intensity variations directly, but has to be obtained from results of other types of measurement such as magnitude estimation. In addition to loudness, loudness level is also important. This is not only a sensation value but belongs somewhere between sensation and physical values. Besides loudness in quiet, we often hear the loudness of partially masked sounds. This loudness occurs when a masking sound is heard in addition to the sound in question. The remaining loudness ranges between a loudness of “zero”, which corresponds to the masked threshold, and the loudness of the partially masked sound is mostly much smaller than the loudness range available for unmasked sound. Partial masking can appear not only with simultaneously presented maskers but also with temporary shifted maskers. The effects of partially masked loudness are both spectral and temporal. [3]

Tonality is one of the Sound Quality metrics that is not yet standardized. It is an important parameter affecting Sound Quality because it is proportional to the human perception of tonal contents in the sound. [4]

Roughness is a complex effect which quantifies the subjective perception of rapid (15-300 Hz) amplitude modulation of a sound. The unit of measure is the asper. One asper is defined as the roughness produced by a 1000Hz tone of 60dB which is 100% amplitude modulated at 70Hz. For a tone with a frequency of 1000Hz or above, the maximal roughness of a tone is found to be at a modulating frequency of 70Hz. Maximal roughness is found to be at increasingly lower modulation frequencies when the carrier frequency is below 1000Hz. A just noticeable difference level in roughness is estimated to be 17%. Roughness has been used to partially quantify sound quality in a number of applications including car engine noise, and in some domestic appliances such as electric razors. It has also been used in the calculation of an unbiased annoyance metric. [3], [6]

Sharpness is a sensation which we can consider separately. But for example, it is possible to compare the sharpness of one sound with the sharpness of another. Sharpness can also be doubled or halved if there are available variables that really change sharpness. The variability of sharpness judgements is comparable to that of loudness judgements. One of the important variables influencing the sensation of sharpness is the spectral envelope of the sound. Many comparisons have indicated that the spectral fine structure is relatively unimportant in sharpness. A noise producing a continuous spectrum, for example, it has the same sharpness as a sound composed of many lines if the spectral envelopes measured in critical-band levels are the same. [3]

3. NOISE MAPPING

For the noise mapping is very important to know environmental noise situations. Those situations consist of complex superposition of natural and technical sounds caused by different sources. But, the subjective evaluation of sound is context dependent and influenced by the attitude and expectation of the listener. The result is in the prediction of the sound quality in a complex situation arising from the superposition of a number of diverse sound sources is very complicated unless the signal processing involved in human hearing is taken into account. [7], [12]

We can say that the sound could be modified by adding or removing of sound sources. However, the total of perceived annoyance depends on the location of the two sound sources relative to the listener. On the other hand, it is possible for an existing sound source of high annoyance to be masked by a second sound source of preferred sound quality. For example, the subjective perceived impulsiveness of individual sound sources can be reduced by adding noise of a comfortable sound quality. [8], [13]

It is needed a mapping with psychoacoustic parameters to predict adequately the sound quality or the annoyance at different places. While it is possible to precisely predict A-weighted sound pressure related to the distance from the noise, such methods of calculation are not applicable for psychoacoustic parameters such as loudness, and particularly sharpness, roughness, and fluctuation strength because they are non linear and the influence of distance is not simple predictable. [19]

4. SUPERPOSITION OF SOUND

The next experiments exemplify how the perception with respect to the known psychoacoustic parameters is generally working. It is needed to comprehend the complex interactions and connections between the human sensation and psychoacoustic parameters. For that purpose, two sounds are superposed. First experiments consists two added sounds; the first sound is white noise with 80 dB(A) and the second sound is 1000 Hz narrow noise band with the same A-weighted level. After that are observed what happens with respect to A-weighted level, loudness, sharpness and roughness by adding these two sounds.

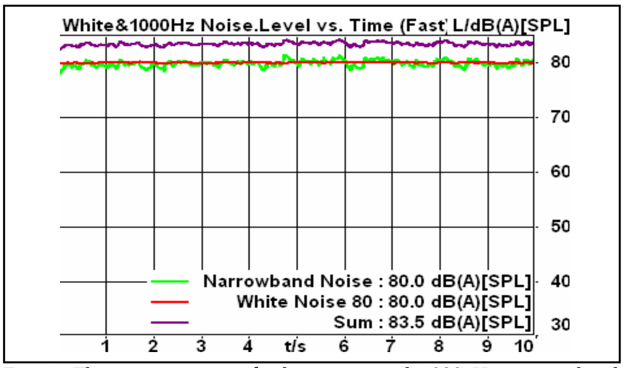

Fig. 1. The superposition of white noise and 1000 Hz narrow band noise: the A-weighted level vs. time

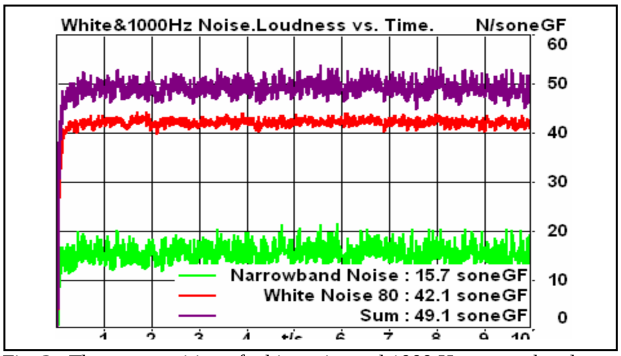

Fig. 2. The superposition of white noise and 1000 Hz narrow band noise: loudness vs. time

The level of 83,5 dB(A) SPL is the sum of the A-weighted level, when the two described sounds are added. The sum of the loudness is only 12% higher in contrast to the 40% increased A-weighted level. It means the same level which results in a different loudness.

Particularly, it can be remarked that the comparable A-weighted levels of the white noise and of the 1000 Hz narrow band noise result in two complete different loudness values, because of the different spectrum – Fig.1 and Fig.2. Moreover, the sum of the sharpness is lower than the sharpness of the white noise. Finally, the sum of roughness is much lesser than the roughness of the narrow band noise – Fig.3 and Fig.4.

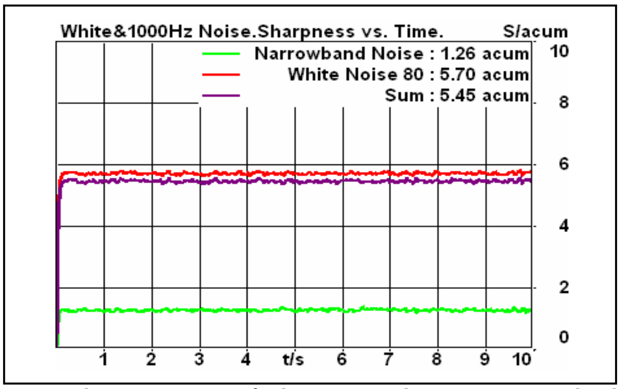

Fig. 3. The superposition of white noise and 1000 Hz narrow band noise: sharpness vs. time

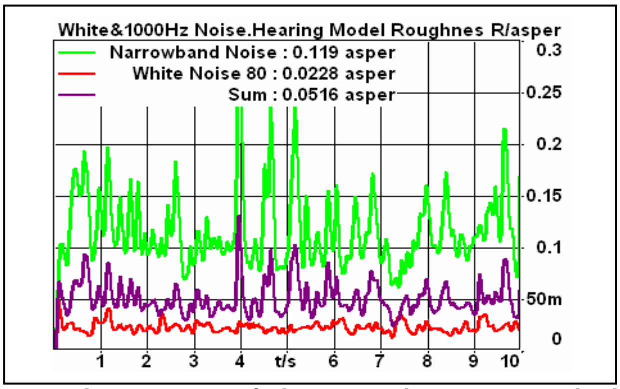

Fig. 4. The superposition of white noise and 1000 Hz narrow band noise: roughness vs. time

By adding of two tonal sounds can be found different consequences. It is generally known that the resulting loudness depends on the spectral distance of the two tones. It has to be considered the masking effect, which can influence the loudness. Moreover, the resulting sharpness depends on the spectral contribution and the resulting roughness depends on the spectral distance of the used tones.

The second experiment is based on the superposition of tones with 1000 Hz and 1070 Hz and both with 80 dB(A) SPL. These tones are close to each other. The characteristics of the A-weighted level and the loudness are not comparable. We can see that in both cases an increased value could be observed, the loudness increases only 3,0 sone, because of the small difference in frequency of the stimuli – Fig.5 and Fig. 6. The value of the sharpness is almost constant in all cases. The curve progression of the roughness points out an extreme increase – Fig.7 and Fig.8.

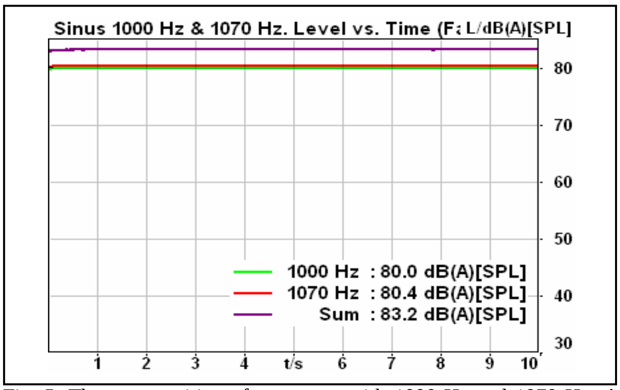

Fig. 5. The superposition of two tones with 1000 Hz and 1070 Hz: A weighted level vs. time

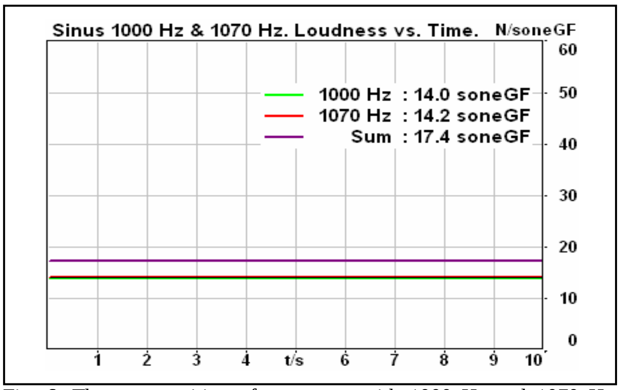

Fig. 6. The superposition of two tones with 1000 Hz and 1070 Hz: loudness vs. time

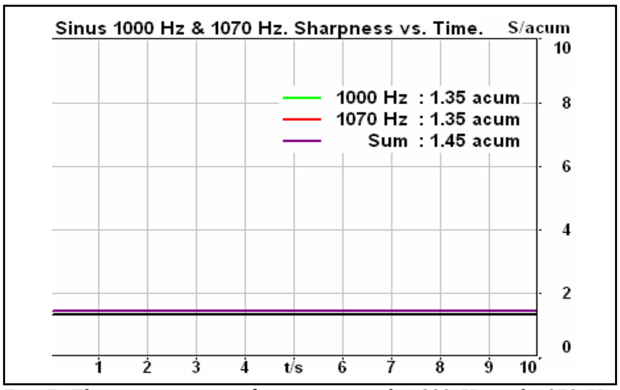

Fig. 7. The superposition of two tones with 1000 Hz and 1070 Hz: sharpness vs. time

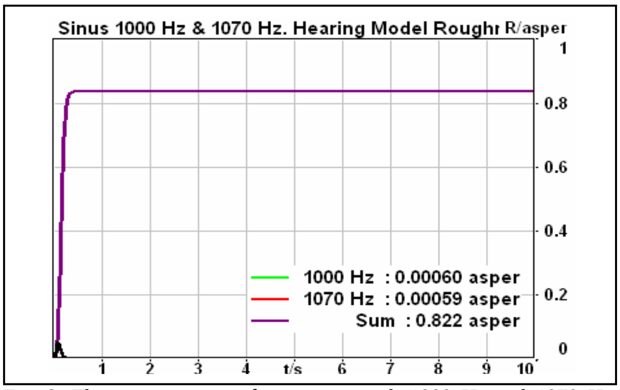

Fig. 8. The superposition of two tones with 1000 Hz and 1070 Hz: roughness vs. time

The third experiment considers of the superposition of two tones, which are not close to each other and excite different critical bands.

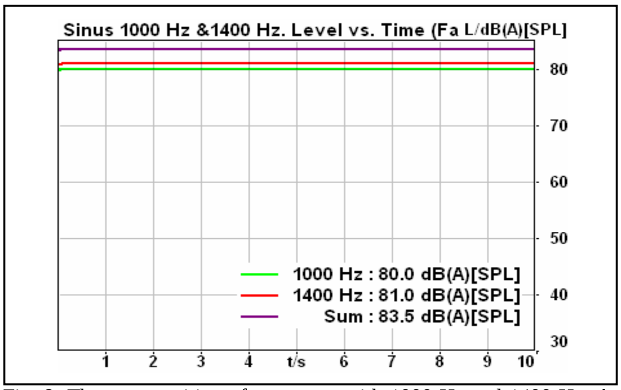

Fig. 9. The superposition of two tones with 1000 Hz and 1400 Hz: A-weighted level vs. time

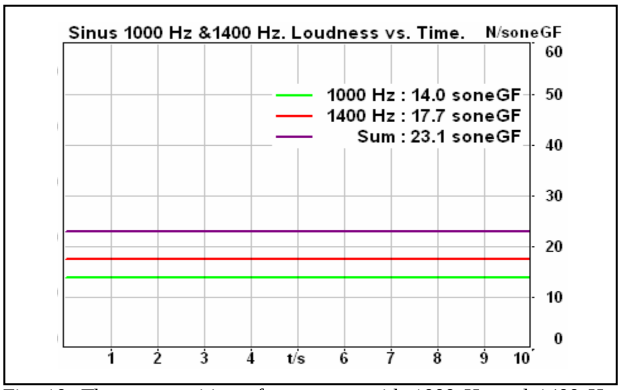

Fig. 10. The superposition of two tones with 1000 Hz and 1400 Hz: loudness vs. time

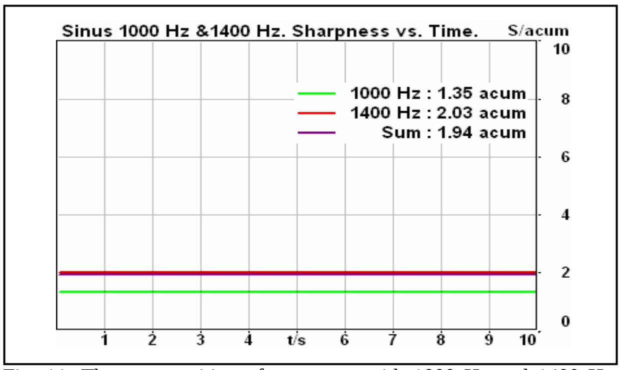

Fig. 11. The superposition of two tones with 1000 Hz and 1400 Hz: sharpness vs. time

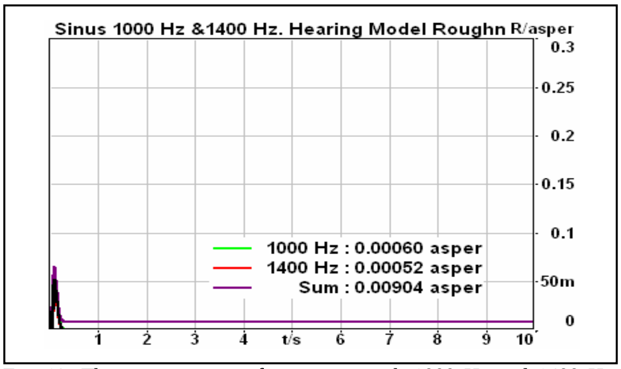

Fig. 12. The superposition of two tones with 1000 Hz and 1400 Hz: roughness vs. time

In this experiment are superposed tones with 1000 Hz and 1400 Hz. The linear sound pressure level of both tones constitutes 80 dB(A) SPL.The following changes with respect to the psychoacoustic parameters could be detected. The characteristics of the A-weighted level and the loudness can be compared.The A-weighted level increased of 40%, the sum of the loudness is 50% higher - Fig.9 and Fig.10 Contrary to these parameters, the sharpness decrease after the superposition of the two tones and the roughness is nearly nonexistent - Fig.11 and Fig.12.

5. CONCLUSION

From the experiments above mentioned is clearly shown that the characteristics of psychoacoustic parameters depend on the nature of the different sounds, which contribute to the overall sound. Altogether, the presented experiments have shown that a complex consideration of the psychoacoustic aspects of sound is necessary in order to comprehend the impact of sound on the human ear and its perception. The A-weighted level and the loudness are not sufficient in describing sounds.

For this experiments is necessary a multidimensional approach which detects adequately the relevant psychoacoustic parameters.

The next step will be focused on measurement in different SPL but in the same level of white noise, narrow band noise or of the noises closer or far to each other. It is necessary to find out the values of parameters in different SPL. Based on these values we can find the changes of human behavior.

6. ACKNOWLEDGEMENTS

This paper has been prepared on the basis of the research project KEGA 049TUKE-4/2012.

7. REFERENCES

[1] R. Gifford: *Environmental Psychology. Principles and Practice.* Newton, Allan and Bacon, Inc. (1987)

[2] Lumnitzer, E. – Badida, M – Polačeková, J.: *Akustika: Základy psychoakustiky.* Košice: TU-SjF, 2012. 121 s. ISBN 978-80-8086-172-8

[3] Eberhard Zwicker - Hugo Fastl: *Psychoacoustics - Facts and models.* 2nd edition. Munich. 1999. ISBN 3-540-65063-6

[4] Z. Zhang – M. Shrestha: *Sound Quality User - Tonality Metric.* IMM, DTU. Brüel & Kjær. 2003 [online]: <http://www2.imm.dtu.dk/pubdb/views/edoc_download.php/2385/pdf/imm2385.pdf>

[5] K. Genuit: *How to evaluate Noise Impact.* Internoise 2003 (Naples, Italy, 2003)

[6] P. Daniel - R. Weber: *Psychoacoustic Roughness: Implementation of an Optimized Model.* Acustica 83, 113~123 (1997)

[7] K. Genuit: *How to influence environmental noise based on psychoacoustic parameters.* Internoise 2000 (Nizza, France, 2000)

[8] K. Genuit: *Virtual binaural auralization of environmental sound situation.* Internoise 1999 (Florida, USA, 1999)

[9] K. Genuit: *The problem of predicting noise annoyance as a function of distance.* Internoise 2001 (Rome, Italy, 2001)

[10] D. Zheng: *Noise Exposure*. In: Fastl, H., Kuwano, S., Schick, A., Recent trends in hearing research, Oldenburg, BIS Verlag (1996)

[11] Džoganová, Z. – Badida, M.: *Psychoakustika v automobilovom priemysle*. In:Strojarstvo Extra. roč. 16, 2012, č. 6, s.10-14. ISSN: 1335-2938

[12] K. Genuit: *Transfer of Knowledge from sound quality measurement to noise impact evaluation.* ASA 2004 (New York, USA, 2004)

[13] Peter Lercher: *Assessing noise pollution in sensitive areas: Soundscape analysis in an alpine valley by psychoacoustic means.* ASA 2004 (New York, USA, 2004)