The Study of Soundscape – COST Training School 2012 on "Measurement, Analysis and Evaluation of Soundscapes"

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Introduction

COST Action TD 0804 on Soundscape of European Cities and Landscapes focuses on a series of actions like considering environmental sounds as a 'resource' rather than a 'waste', promoting health and sustainability, enhancing the quality of life. Between 16th and 20th of July 2012, the Training School named "Measurement, Analysis and Evaluation of Soundscapes" was carried out as a theoretical and practical course in the company HEAD acoustics and in the city of Aachen, Germany.

The lecturers were distinguished professors and researchers in the soundscape field:

- Prof. Dr. B. Schulte-Fortkamp
- Prof. Dr.-Ing. K. Genuit
- A. Fiebig M.A.

The participants were 17 young researchers from different European universities. During the lectures the students were introduced to the theoretical concepts of soundscape, after which they performed in-situ and laboratory measurements and analysis of their results.

This paper describes the soundscape case study which included soundwalks, psychoacoustic measurements and laboratory listening tests. The aim was to evaluate the investigated urban soundscape by collecting, analysing, correlating and interpreting the obtained data, and the results are presented and discussed here.

Soundscape and soundwalks

The term soundscape represents the acoustic environment that is evoked by physical sound sources and perceived by human listeners. It is important that it is context dependent, i.e., dependent on the input of other sensory modalities, the purpose of the space, the individual sonic and cultural background and the activities and motivations of people. The soundscape is mainly used in the context of outdoor spaces but is not limited to this [1].

Furthermore, the soundscape means a concept of evaluating and designing acoustic environments. This concept has been formed in the 1970s when a group of researchers in Vancouver started the "World Soundscape Project" [2]. The leading researcher in this project, R. Murray Schafer, and his book [3] established the line of thinking that forms the basis of a paradigm shift in the way that environmental acoustics and noise are evaluated nowadays.

The soundscape demands a holistic approach for the analysis of environments. In the analysis process, not only physical parameters (sound levels) but also psychoacoustic parameters (loudness, roughness, sharpness, etc.) and qualitative data (interviews, questionnaires) play a major role. Psychoacoustic parameters allow for a human hearing related analysis that reflects better on how people perceive a soundscape [4]. However, especially interviews and questionnaires make the difference because the context and information content aspects of a soundscape can then be assessed [5] [6].

A technique that has found a wide acceptance in the soundspace research is the soundwalk method. It is an in-situ listening of an environment while making ratings and comments and thus gathering impressions on the soundscape. With this method the change in the soundscape and its relationship to the architecture and the activities of people can be evaluated [7].

During the Training School two groups of participants carried out a soundwalk throughout the city of Aachen (figure 1). Eight places, chosen for the measurements and evaluation, represented the urban diversity of the city, and were the same as in the previous years of the Training School. Short description of the evaluated places is as follows:

1. Intersection of busy streets close to the historical city gate
2. Intersection between a pedestrian area with many restaurants and a street with road traffic
3. Pedestrian area with shops and restaurants with terraces on the street
4. Intersection point with traffic lights between a pedestrian area and a busy street
5. Square near Rathaus with a fountain and some cafeterias
6. Rectangular square surrounded by historic buildings with no commercial activity
7. Extensive green area full of people and surrounded by shops
8. Square in front of a street used only for public transportation

Figure 1: Eight places of Aachen urban area where the soundwalk was conducted.

Perceptual ratings analysis

The participants understanding and perception of the soundscape in focus was obtained by gathering of the perceptual data. The nine participants of group 2 in the Training School evaluated the perceived loudness and unpleasantness on the subjective rating scales. Additionally, participants were asked to note the audible sound sources as well as their feelings and thoughts evoked by the environment.

The presence of the sound sources from the participants notations was later described by categorising the sources into the following three categories:

1. Natural sounds – birdsong, barks, water
2. Human non-mechanical sounds – voices, footsteps, music, bells
3. Mechanical sounds – road traffic, construction noise, aircraft

Occurrence of audible sound sources differs for each of the place as it is shown in the examples on the figure 2.

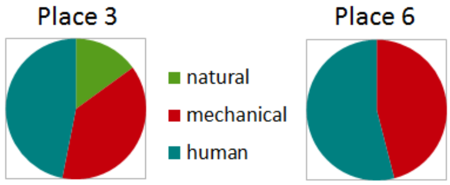

Figure 2: Difference in audible sound sources on the third and sixth evaluation place.

Psychoacoustic measurements

Further soundscape understanding is provided by psychoacoustic analysis. Parameters related to psychoacoustics tend to model the certain processes of human hearing to extract the single value from acoustical data.

The equipment consisted of binaural headset (fitted on different persons at each of eight measurement places) and SQuadriga II recorder. The binaural microphones were used to capture the spatial properties of soundscape which was important for reproduction in further laboratory testing. The measurement duration was about three minutes at each location.

Analysis of the obtained recordings was made using the ArtemiS software provided by HEAD acoustics. With it, the participants had been given the opportunity to calculate different psychoacoustic values. Also, all of the recordings were cut to the same length so that the calculations were made on same portions of audio data for each place.

Moreover, it should be noted that the analysis of the recordings was carried out for both ears signals. The results here are presented separately so the difference between the two ears can be observed. However, the comparison of these values with the subjective ratings of soundscape required the metric for combining the left and right ear microphone value into one[1].

Additionally, the percentile values, which represent the values exceeded in certain percentage of duration of the recorded sound, were also obtained. The acoustical analysis was focused on the following parameters:

- Equivalent continuous sound pressure level (L_{Aeq})
- Loudness (DIN 45631/A1) (N)
- Sharpness (DIN 45631/A1, Aures model) (S)
- Hearing model roughness (HMR)
- Relative Approach (RA)

Graphical representation for the calculated percentile loudness for each of eight measurement places[2] is shown in the figure 3. There it can be seen that 50- and 90-percentile values have a lower variation among places

[1] Selected metrics were either average or maximum values between the left and right ear.

[2] First and second place were recorded twice for additional analysis of soundscape change over short time.

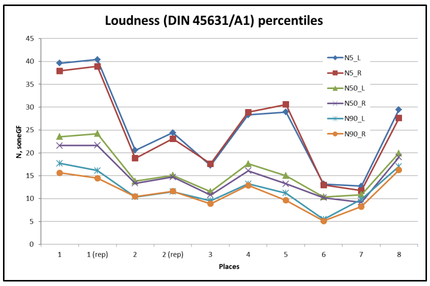

Figure 3: Representation of calculated loudness percentile values for all measurement places.

than the 5-percentile values. Also, the left and right microphone values differ slightly in this figure, whereas for Relative Approach (figure 4) the difference between channels is relatively high. The results from the analysis of the *RA* parameter show that the strength of noise patterns can vary considerably between the two ears at different locations almost independent from loudness or level, which did not show great interaural differences.

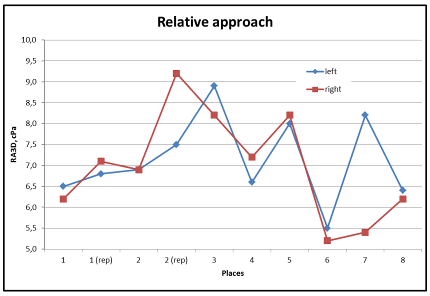

Figure 4: Representation of calculated Relative Approach values for all measurement places.

Comparison of psychoacoustic and perceptual measures

The obtained values from acoustical data provided the possibility of comparison with the perceptual data. The comparison was done by correlation of the psychoacoustic and perceptual parameters. Correspondingly, comparisons can be shown by regression graphs with plotting of the calculated measures on the x-axis versus their correspondent perceptual parameters on the y-axis.

Figures 5 and 6 show comparison between measured loudness percentiles and perceived loudness, and better correlation has been found with 50-percentile loudness. Therefore, a better loudness predictor, with respect to the data of this case study, seems to consider a median loudness value instead of high values that are found in the 5 percent of the sound duration.

Additionally, the second order polynomial regression models are shown in figures 7 and 8. From the obtained data and graphs shown, it can be seen that the increase of intensity oriented parameter, such as equivalent continuous sound pressure level, could indicate a higher unpleasantness and loudness perceptual ratings. However, that parameter alone cannot explain the differences in perceived loudness and unpleasantness.

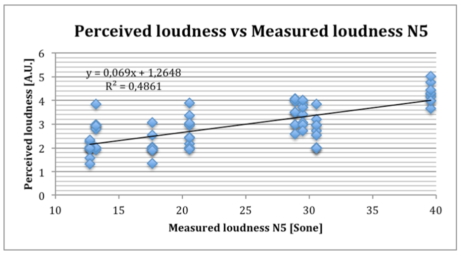

Figure 5: Regression model of the measured 5-percentile loudness and the perceived loudness.

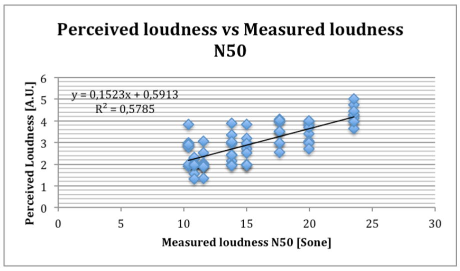

Figure 6: Regression model of the measured 50-percentile loudness and the perceived loudness.

Laboratory tests and comparison with soundwalks

The laboratory test was performed for eight locations evaluated in the soundwalk. Nine participants of the soundwalk also participated in the laboratory test. Binaural soundscape recording from every location was reproduced over headphones, in duration of 90 seconds (starting at 30 seconds from the full 3 minute recording) and participants were asked to evaluate the perceived subjective loudness and unpleasantness. Also, the process was repeated for three selected locations (audio duration of 70 seconds, starting at 30 seconds in the

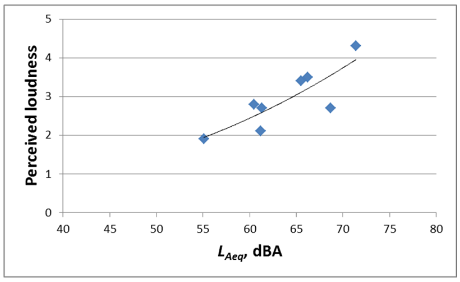

Figure 7: Regression model of the measured equivalent continuous sound pressure level and the perceived loudness.

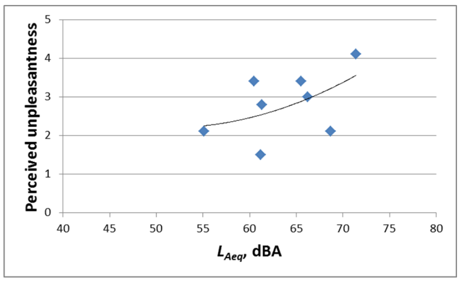

Figure 8: Regression model of the measured equivalent continuous sound pressure level and the perceived unpleasantness.

original recording), but with the reproduction of the corresponding location picture on the projection screen.

Recordings were reproduced in the original level, due to the calibrated measurement and reproduction chain. While a continuous five point scale was used for the field evaluation, in the laboratory test a discrete nine point scale was presented to the participants. The average results of perceived loudness and unpleasantness from soundwalk field evaluation are compared with the average results from the laboratory test (figures 9 and 10).

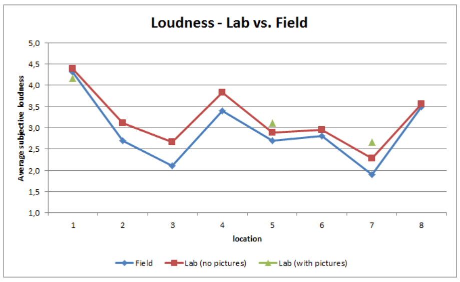

Figure 9: Average subjective grades for loudness in field and laboratory evaluation.

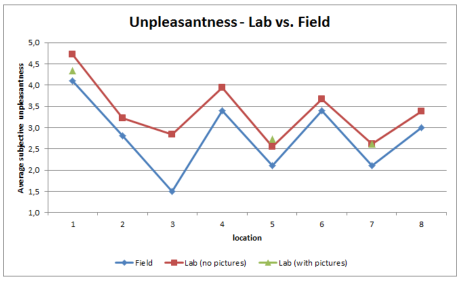

Figure 10: Average subjective grades for unpleasantness in field and laboratory evaluation.

Both of the graphs show higher loudness and unpleasantness grades for the laboratory tests without pictures. That could be a result of the isolated acoustical information (without the context of other senses) and the participants attention was focused on the sound. The trends shown in both graphs are quite consistent throughout the places for loudness and unpleasantness ratings.

Conclusions

In this paper the case study of measurement, analysis and evaluation of urban public areas in Aachen was presented. Comparison of psychoacoustic measures from the binaural recordings and ratings obtained from participants evaluation was provided by calculation of the correlation coefficients as well as the regression models.

In conclusion from the obtained results, laboratory soundscape evaluation could provide a good preliminary trend assessment. However, the data obtained from the laboratory test show that the visual sensation also influences the perception of soundscape. Moreover, the psychoacoustic measures provide comparative values for assessment on how the human hearing is stimulated by the soundscape. Additionally, some of their regressions with the perceptual parameters are found to be of significance. Nevertheless, they alone could not explain the different layers of people's perception evoked by the sound sources, context and emotions towards soundscape.

Consequently, evaluation with the psychoacoustic measures, as well as the perceptual data, is of significance for soundscape description and determination of soundscape impact on people. Moreover, only one analysis method would not be sufficient for obtaining the detailed results for a soundscape study and for drawing valid conclusions.

Acknowledgements

The participants of the COST Training School 2012 would like to thank the three institutions: COST Action TD 0804 on Soundscape of European Cities and Landscapes, HEAD acoustics GmbH and the Technische Universität Berlin for the financial, organisational and academic support provided for their education in the soundscape research field.

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