Citizens' perceptual evaluation of noise events in an urban environment

Rosa Ma Alsina-Pagès[1], Ferran Orga[1], Marc Freixes[1] and Maria Foraster[2]

[1] Grup de recerca en Tecnologies Mèdia (GTM), La Salle – Universitat Ramon Llull, c/Quatre Camins, 30, 08022 Barcelona (Spain)

[2] ISGlobal, Barcelona (Spain)

Corresponding author's e-mail address: rosamaria.alsina@salle.url.edu

ABSTRACT

Noise is one of the main environmental pollutants and represents a public health concern due to its wide impact, among others, on annoyance and citizens' quality of life. Real-time noise monitoring can help authorities in decision-making and policy design to address this problem. In this respect, several Wireless Acoustic Sensor Networks (WASN) have been deployed, mainly in European and American countries, focusing on critical locations as big cities. These networks mainly measure the noise levels associated to road traffic. However, other types of sounds may be found in urban areas. In this work, we propose the analysis of a dataset collected through a WASN in the urban area of Milan, which contains several common noise events such as dogs barking, sirens, horns, trains, among others. In order to evaluate how citizens perceive these sounds we have designed a set of off-line listening tests. Participants are asked not only to rate the degree of annoyance but also other qualities such as loudness, sharpness or pleasantness. Moreover, psychoacoustic parameters of the evaluated audios are extracted and compared with the tests results to look for relationships.

INTRODUCTION

Literature shows that noise is currently one of the main environmental pollutants affecting the health of people living specially in urban areas [1,2]. The common effects of noise pollution on people's health includes cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus and annoyance [3]. In response to this situation, the World Health Organisation (WHO) has recently released a new set of environmental noise guidelines [4].

In order to automatically monitor the noise levels, several projects have deployed Wireless Acoustic Sensor Networks (WASNs), which allow data gathering for noise mapping [5,6]. Nevertheless, WASNs typically describe environmental noise using the L_{Aeq} values, without taking into account the sound sources. In this context, the LIFE DYNAMAP project has deployed a sensor network that monitors traffic related to road traffic [7], which incorporates

an Anomalous Noise Event Detector (ANED) in order to discard any other noise event but Road Traffic Noise (RTN) in the computation of the traffic noise maps.

Although ANEs have been generally left out of the scope of noise mappings, they do form part of the urban sonic environment and should therefore be considered. Indeed, ANEs do influence people's perception of the environment and they can also cause annoyance and health problems. For this reason, the soundscape approach suggests the assessment of all sounds perceived by a person or a group of people [8]. Most studies on acoustic pollution attempt to link the annoyance caused by noise to their equivalent level L_{Aeq}. However, there are other acoustical characteristics of sound that are closer to how humans perceive sounds, such as the psychoacoustic parameters defined by Zwicker [9].

This work is a first approach to study the degree of annoyance caused by the different types of acoustic events occurring in the daily life in an urban environment. We propose to assess the acoustic environment of the citizens through a perceptual-oriented approach based on the data obtained by means of a 24-sensor WASN deployed in the city of Milan in the framework of the LIFE DYNAMAP project [7]. The goal is to determine, through off-line perceptual tests conducted with 100 participants, which type of usual urban sound is considered most annoying by people, and how sound annoyance can be related to two psychoacoustic parameters (loudness and sharpness).

This first approach has considered three types of test:

- Pair-wise comparison: we have asked the participants to choose the most annoying of two samples of the same type of sound, collected in the same sensor and with similar loudness levels and different sharpness values, in order to determine the relevance of the sharpness in the annoyance within the set of samples used in the test.
- Sensations test: after selecting several relevant acoustic events (sirens, horns, dogs barking, etc), we have asked the participants to use a 5-point Likert scale to evaluate the degree of agreement with different adjectives describing the sound (loud, shrilling, disturbing, sharp, or pleasant)
- MUSHRA [10] test: this is a multiple sound evaluation test that consists of several sets. For each of the sets, we have selected several sounds of various types with similar loudness and sharpness coming from the same sensor of the WASN, and we have asked the participants to put them in order from most annoying to less annoying in a 0-100 scale.

RESULTS

The results of the pair-wise comparison test [11] are almost divided in terms of the sharpness comparison between the two audios under test. Nevertheless, the results showed that there is a high dependency between the results and the type of sound analysed (door, airplane, works, bird, horn, etc.).

The evaluation of the pair-wise comparison test has led us to deepen the analysis of the other two tests [12]. With more than 100 tests conducted, which is the most pleasant sound in the Sensations test? According to the results, none of the presented sounds is really classified as pleasant, but the less annoying one is People, as well as the most disturbing is the truck, or the most strident is the siren. This first approximation to the results encourages us to deepen the analysis for the Sensations test.

Finally, the results of the MUSHRA test show several coincidences even for different groups of sounds collected in different sensors. The siren, if present in the set of sounds under test, is always classified as the most annoying of all sounds, followed by work construction sounds and horns. The least annoying sounds usually correspond to birds or people. We envisage promising results in the MUSHRA evaluation, due to the fact that we can work not only with the annoyance values assigned to all and each of the samples, but also analyse the relationship between the values of the different sounds in the same set.

CONCLUSIONS

The preliminary analysis conducted through the three types of tests, in which 100 people participated, encourage us to keep working on the obtained data. Further analysis should be done, evaluating not only the answers of the participants, but also considering the bias that their age, gender and living-area can introduce in the results.

The long-term objective is to observe the dependencies between the psychoacoustic parameters measured in real-operation settings and the annoyance perceived by the citizens, considering the several types of test conducted.

Acknowledgements

The research presented in this work has been partially supported by the LIFE DYNAMAP project (LIFE13 ENV/IT/001254). Ferran Orga thanks the support of the European Social Fund and the Secretaria d'Universitats i Recerca del Departament d'Economia i Coneixement of the Catalan Government for the pre-doctoral FI grant No. 2019 FI B2 00168. Maria Foraster is supported by a Beatriu de Pinós fellowship [2018/8374/I] awarded by the Universities and Research Secretariat of the Catalan Ministry of Business and Knowledge.

REFERENCES

[1] HF Guite, Charlotte Clark, and Gill Ackrill. The impact of the physical and urban environment on mental well-being.Public health, 120(12):1117–1126,2006.

[2] Otto Hanninen, Anne B Knol, Matti Jantunen, Tek-Ang Lim, André Conrad, Marianne Rappolder, Paolo Carrer, Anna-Clara Fanetti, Rokho Kim,Jurgen Buekers, et al. Environmental burden of disease in europe: assessing nine risk factors in six countries. Environmental health perspectives,122(5):439, 2014.

[3] World Health Organization and the Joint Research Centre of the European Commission. Burden of disease from environmental noise: Quantification of healthy life years lost in Europe. Technical report, World Health Organization. Regional Office for Europe, 2011.

[4] World Health Organization. Environmental Noise Guidelines for the European Region. Technical report, 2018.

[5] Dick Botteldooren, Luc Dekoninck, and Dominique Gillis. The influence of traffic noise on appreciation of the living quality of a neighborhood. International journal of environmental research and public health, 8(3):777–798, 2011.

[6] Oded Nov R. Luke Dubois Anish Arora Justin Salamon Charles Mydlarz Juan P. Bello, Claudio Silva and Harish Doraiswamy. SONYC: A System for Monitoring, Analyzing, and Mitigating Urban Noise Pollution. Communications of the ACM, 62(2):68–77, 2019.

[7] Xavier Sevillano, Joan Claudi Socoró, Francesc Alías, Patrizia Bellucci, Laura Peruzzi, Simone Radaelli, Paola Coppi, Luca Nencini, AndreaCerniglia, Alessandro Bisceglie, Roberto Benocci, and Giovanni Zambon.DYNAMAP – Development of low cost sensors networks for real time noisemapping.Noise Mapping, 3:172–189, May 2016.

[8] ISO FDIS. 12913-2: 2018 acoustics - soundscape - part 2: Data collectionand reporting requirements. International Organization for Standardization: Geneva, Switzerland, 2018.

[9] Eberhard Zwicker and Hugo Fastl.Psychoacoustics: Facts and models,volume 22. Springer Science & Business Media, 2013.

[10] ITURBS Recommendation. 1534-1: Method for the subjective assessment of intermediate quality level of coding systems.International Telecommunication Union, 2003

[11] Labairu-Trenchs, A., Alsina-Pagès, R. M., Orga, F., & Foraster, M. (2018). Noise Annoyance in Urban Life: The Citizen as a Key Point of the Directives. In *Multidisciplinary Digital Publishing Institute Proceedings* (Vol. 6, No. 1, p. 1).

[12] Rosa Ma Alsina-Pagès, Marc Freixes, Ferran Orga, Maria Foraster & Alexandra Labairu-Trenchs (2020): Perceptual evaluation of the citizen's acoustic environment from classic noise monitoring, Cities & Health, DOI: 10.1080/23748834.2020.1737346.