



## Subjective evaluation of environmental sounds in context - towards Soundscape Indices (SSID)

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### ABSTRACT\*

The subjective evaluation of environmental sounds is always affected by the context, including the interrelationships between person and activity and place, in space and time, as defined in ISO 12913. Based on Soundscape Indices (SSID), an ongoing European Research Council (ERC) Advanced Grant project, this paper presents a soundscape approach, where contextual factors are taken into account. The following works are briefly introduced: (1) The SSID protocol for field surveys and the corresponding International Soundscape Database (ISD); (2) Analysis of the effects of various factors, especially contextual factors, where differences in various languages and cultures are also considered; (3) Soundscape prediction models towards Soundscape Indices (SSID), which, by integrating the effects of context, will adequately reflect levels of human comfort, compared to decibel-based metrics. The SSID is in two forms/levels, a set of indices for aiding designs, and a single index for ranking different designs.

**Keywords:** *soundscape, sound evaluation, context, soundscape index*

### 1. INTRODUCTION

The subjective evaluation of environmental sounds is always affected by the context, including the

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interrelationships between person and activity and place, in space and time, as defined in ISO 12913 [1]. Based on Soundscape Indices (SSID), an ongoing European Research Council (ERC) Advanced Grant project [2-3], this paper discusses the effects of contextual factors, aiming at developing soundscape indices which go beyond conventional decibel system.

### 2. SSID PROTOCOL AND DATABASE

A SSID protocol has been developed, which consists of two stages: a Recording Stage, where First-Order (or higher) Ambisonics recordings are made simultaneously with 360° video which can be reproduced in a virtual reality environment, and a Questionnaire Stage, where in situ assessments are collected via a questionnaire method paired with acoustic data collection [4]. Based on the data collected under the protocol, a large-scale, International Soundscape Database (ISD) has been established, with 4,000 participants from worldwide locations and at each location around 100 questionnaires were collected over a series of multi-hour long sessions. It is the intention that this open dataset be added to and augmented with new locations, cities, and contexts in the future, by any researchers and practitioners [5]. In order to support the use of the ISD, *soundscapepy*, a python library for analysing and visualising soundscape assessments, has been developed [6]. Soundscape assessment data visualization is an important tool for researchers and practitioners because it supports data analysis, enhances communication, facilitates decision making and helps in comparisons.

### 3. EFFECTS OF CONTEXTUAL FACTORS

Based on the SSID database, relationships among psychological, (psycho)acoustical, neural and physiological,

and contextual factors, as well as their effects on soundscape descriptors, have been examined. Linear mixed-effects modelling applying backwards-step feature selection was used to model the interactions between internal factors including psychological well-being, age, gender, occupation status, education levels and the soundscape Pleasantness and Eventfulness, while accounting for the random effects of the survey location, namely, the context. It was shown that internal factors account for approximately 1.4% of the variance for Pleasantness and 3.9% for Eventfulness, while the influence of the locations accounted for approximately 34% and 14%, respectively [7]. Parallel works have also been carried out by considering other kinds of places ranging from mountain landscape to temples, to indoor spaces, also by considering a range of users such as blind and older people [8]. Cross-cultural differences have also been examined, where the possible differences caused by translation in different languages are also taken into account, with translation into 19 different languages obtained through focus groups and panels of experts [9,10].

#### 4. PREDICTION MODELS TOWARDS SOUNDSCAPE INDICES

For the design and planning of sound environments, it is important to predict soundscape indices [11], which could be in two forms/levels, a set of indices for aiding designs, such as Pleasantness and Eventfulness, and a single index for ranking different designs. An example/application of such a prediction was that the unprecedented lockdowns resulting from COVID-19 triggered changes in context, especially in human activities in public spaces, and therefore it would be useful to predict the changes in the perception of the sound environment when people could not be surveyed but sound recordings could be made. Using these 30-s-long recordings, linear multilevel models were developed to predict the soundscape pleasantness ( $R^2=0.85$ ) and eventfulness ( $R^2=0.71$ ) [12]. This study demonstrates the usefulness of predictive modelling and the importance of considering contextual information.

#### 5. CONCLUSIONS

With the large-scale SSID database, the effects of context have been demonstrated and integrating such effects in the soundscape indices prediction model will adequately reflect levels of human comfort, which could be used to replace decibel-based metrics. Overall, the soundscape approach being promoted by the Soundscape Indices (SSID) project,

is an important advance in the field of environmental sound evaluation, offering a more comprehensive and culturally sensitive method for understanding and improving the soundscape.

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#### 7. REFERENCES

- [1] International Organization for Standardisation: *ISO 12913-1:2014. Acoustics – Soundscape – Part 1: Definition and conceptual framework*. ISO, 2014.
- [2] J. Kang, F. Aletta, T. Oberman, M. Erfanian, M. Kachlicka, M. Lionello, and A. Mitchell, “Towards soundscape indices,” in *Proceedings of 23rd International Congress on Acoustics, integrating 4th EAA Euroregio 2019*, (Aachen, Germany), pp. 2488-2495, 2019.
- [3] J. Kang, F. Aletta, T. Oberman, A. Mitchell, and M. Erfanian, “On the development of soundscape indices (SSID),” in *Proceedings of the 52nd International Congress and Exposition on Noise Control Engineering*, (Chiba, Japan), 2023.
- [4] A. Mitchell, T. Oberman, F. Aletta, M. Erfanian, M. Kachlicka, M. Lionello, and J. Kang, “The Soundscape Indices (SSID) Protocol: A method for urban soundscape surveys-Questionnaires with acoustical and contextual information,” *Applied Sciences*, vol. 10, 2397, pp. 1-27, 2020.
- [5] A. Mitchell, T. Oberman, F. Aletta, M. Erfanian, M. Kachlicka, M. Lionello, and J. Kang, *The International Soundscape Database: An integrated multimedia database of urban soundscape surveys – questionnaires with acoustical and contextual information (0.2.2) [Data set]*. Zenodo. <https://doi.org/10.5281/zenodo.5705908>, 2021.
- [6] A. Mitchell, F. Aletta, and J. Kang, “How to analyse and represent quantitative soundscape data,” *JASA Express Letters*, vol. 2, 037201, 2022.
- [7] M. Erfanian, A. Mitchell, F. Aletta, and J. Kang, “Psychological well-being and demographic factors can mediate soundscape pleasantness and eventfulness: A large sample study,” *Journal of Environmental Psychology*, vol. 77, 101660, 2021.
- [8] J. Kang, F. Aletta, T. Oberman, A. Mitchell, and M. Erfanian, “On the development of soundscape indices (SSID),” in *Proceedings of the 29th International Congress on Sound and Vibration*, (Prague, Czech Republic), 2023.
- [9] F. Aletta, T. Oberman, Ö. Axelsson, H. Xie, Y. Zhang, S. K. Lau, ... and J. Kang, “Soundscape assessment: Towards a validated translation of perceptual attributes in different languages,” in *Proceedings of the 49th International Congress and Exposition on Noise Control Engineering*, (Seoul, Korea), 2020.
- [10] N. Papadakis, F. Aletta, J. Kang, T. Oberman, A. Mitchell, and J. Stavroulakis, “Translation and cross-cultural adaptation methodology for soundscape attributes - A study with independent translation groups from English to Greek,” *Applied Acoustics*, vol. 200, 109031, 2022.
- [11] F. Aletta, J. Kang, and Ö. Axelsson, “Soundscape descriptors and a conceptual framework for developing predictive soundscape models,” *Landscape and Urban Planning*, vol. 149, pp. 65-74, 2016.
- [12] A. Mitchell, T. Oberman, A. Aletta, M. Kachlicka, M. Lionello, M. Erfanian, and J. Kang, “Investigating urban soundscapes of the COVID-19 lockdown: A predictive soundscape modeling approach,” *Journal of the Acoustical Society of America*, vol. 150, pp. 4474-4488, 2021.