Soundscape Assessment at a University Campus in Detmold, Germany

Balderrama, Alvaro; Erol, Aylin; Götz, Johanna; Luna-Navarro, Alessandra; Kang, Jian; Arztmann, Daniel; Knaack, Ulrich

Publication date
2023

Document Version
Final published version

Published in
Healthy Buildings Europe 2023

Citation (APA)
Balderrama, A., Erol, A., Götz, J., Luna-Navarro, A., Kang, J., Arztmann, D., & Knaack, U. (2023). Soundscape Assessment at a University Campus in Detmold, Germany. In *Healthy Buildings Europe 2023: Beyond Disciplinary Boundaries* (pp. 841-846). (Healthy Buildings Europe 2023: Beyond Disciplinary Boundaries; Vol. 2). International Society of Indoor Air Quality and Climate - ISLAQ.

Soundscape Assessment at a University Campus in Detmold, Germany

Alvaro Balderrama [a,b], *Aylin* Erol [c], *Johanna* Götz [d], *Alessandra* Luna-Navarro [a], *Jian* Kang [e], *Daniel* Arztmann [b], *Ulrich* Knaack [a]

[a] Architectural Façades and Products Research Group, Faculty of Architecture and Built Environment, TU Delft, Delft, The Netherlands.

[b] Institute for Design Strategies, Detmold School of Architecture and Interior Architecture, University of Applied Sciences and Arts Ostwestfalen-Lippe (TH OWL), Detmold, Germany.

[c] Faculty of Architecture and Design, Ozyegin University, Istanbul, Turkey.

[d] Faculty of Music Pedagogy, Theory and Composition (FB3), Detmold University of Music (HfM), Detmold, Germany.

[e] Institute for Environmental Design and Engineering, The Bartlett, University College London, London, UK.

Abstract. People in cities are constantly exposed to complex combinations of sounds, some originating from nature along with some created by human activities like traffic noise, sounds of industrial machinery, or music. This research aimed to study how the acoustic environment of a university campus is perceived by people. The procedures for soundscape data collection and analysis were based on the ISO 12913 series. 30 volunteers divided into four groups participated in a "soundwalk" at the campus of the architecture school in Detmold, Germany, filling out questionnaires while sound measurements and recordings were being taken. After the soundwalk, the data from the questionnaires, sound measurements, recordings, pictures and videos were analyzed. The results suggest that people's perception of sound at the campus was susceptible to the ongoing activities taking their attention such as sounds from children playing, a construction site, music and other groups of people. The results provide new evidence and insights about the soundscape of the university campus and can inform stakeholders to improve environmental quality.

Keywords. Soundscape, soundwalk, acoustic environment, context, perception, ISO 12913

1. Introduction

As cities develop over time, they usually become more populated, dense and complex, influencing the quality of spaces where people carry out their daily activities. Human comfort, whether indoors or outdoors relies on the interpretation of information received by multiple senses, leading to visual, thermal, acoustic and air quality comfort. Noise in cities is a concerning environmental stressor and mitigating its negative impacts has been a priority for the past decade at governmental and international levels (World Health Organization, 2011; United Nations, 2015; World Health Organization, 2018). Its negative effects on people's health and well-being range from annoyance and sleep disturbance to aggravation of cardiovascular diseases and premature death (European Environment Agency, 2014). Noise also has a disruptive impact on wildlife (Aletta, 2022). The turn of the century has seen an increase in human-centered design attempts placing people's benefit as the main aim, and the concepts of ergonomics and participatory design among others have been developed (Auernhammer et al., 2022). In a similar manner, the general understanding of noise as a decibel level that should be limited has also been shifting towards an approach that considers sounds as a resource that when managed adequately can be used to improve people's experience of the city. Since the pioneering studies of the interdiscipline entitled "soundscape" in the 1960s and 1970s (Schafer, 1969; Southworth, 1969; Schafer, 1977), the concept has been applied in multiple fields and increased steadily over the years (Yang and Lu, 2022; Kang, 2023).

According to Aletta and Xiao (2018), bridging the gap between academic research on soundscape and its practical applicability for design and engineering is one of the main ongoing challenges in the field, its ties to architectural applications are still not established (Xiao et al., 2022). Several methods and tools for soundscape data collection have been presented and validated throughout the years, and among the most applied methods for soundscape assessment is the "soundwalk". A soundwalk, as described by ISO

12913, is a method that implies walking in an area focused on listening to the acoustic environment. According to Aletta et al. (2016) soundwalks are conducted in situ and participants walk in silence listening to the acoustic environment; At given locations along the walk, they are asked to fill in a questionnaire and they might participate in an interview about their impressions of the area; additionally, audio recordings and acoustic measurements are taken during the soundwalk. The integration of data from questionnaires (perceptual attributes) and physical sound measurements is a common approach in soundscape studies (Mancini et al., 2021).

Although university campuses cover a limited area of the built environment, they host multiple events, from academic to social activities. Investigating these spaces is relevant to understand the contextual conditions for large numbers of people. In order to address the research question of how is the soundscape of a typical university campus, a soundwalk was conducted at the Detmold School of Architecture and Interior Architecture on September 22nd, 2022.

2. Methods

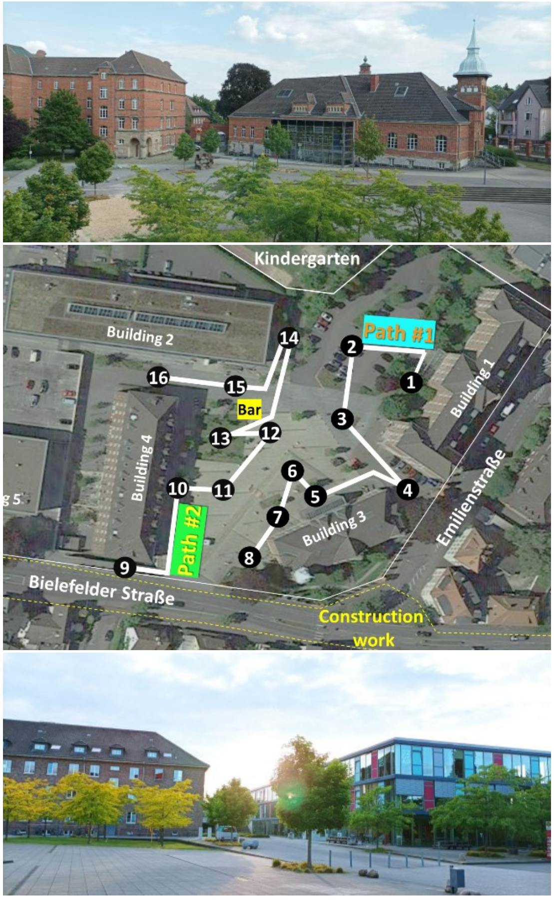
The definitions and conceptual framework for soundscape research provided by Part 1 of the ISO 12913 series (International Organization for Standardization, 2014) were adopted. The applicable methods and tools for soundscape data collection and analysis established in Part 2 of the standard (International Organization for Standardization, 2018) were considered and integrated with the questionnaire of the Soundscape Indices Protocol (Mitchell et al., 2020). The data analysis followed procedures indicated in Part 3 of the standard (International Organization for Standardization, 2019).

2.1 Study design

The main outdoor space of the campus is where most of the social activities take place and is surrounded by four buildings. The two paths, namely Path #1 and Path #2 with 8 stops per path are seen in Figure 1, resulting in a total of 16 representative areas. The criteria to select the paths was that each group should experience different situations (quiet, loud, surrounded by buildings or vegetation). Also, the paths were not supposed to cross each other to avoid interference between groups.

Figure 1

Campus of the Detmold School of Architecture and Interior Architecture of TH OWL in Detmold, Germany. Two paths and the 16 areas chosen for the soundwalk.



The soundwalk was organized during the first week of the academic semester, so additional activities took place such as the setup of a beer bar that would play music. Also, the campus is neighbouring a kindergarten. Coincidentally, there were construction works going on at the Bielefelder Straße and the intersection with Emilienstraße (Figure 2), so the possibility of construction noise was considered in the study design for comparison between groups (e.g. with vs. without construction noise).

Figure 2

Construction site at the intersection of Bielefelder Straße and Emilienstraße.

2.2. Data collection

This pilot study considered methods that were suitable and feasible in order to survey people (via questionnaire), the acoustic environment (via audio recordings; sound level measurements in dBA; frequency spectrum) and the context (via photos; videos; weather data)

Before the data collection on site, participants were gathered in a classroom and the intentions of the activity were explained. A printed information sheet was presented to each participant and it was read out loud by the researchers. Then, each participant voluntarily signed a consent form. Finally, participants were guided outdoors to survey the soundscape on their respective paths.

Regarding the questionnaire, part 2 of the ISO 12913 series provides two alternatives for data collection: Method A and Method B. Aletta et al. (2019) explored the compatibility of both methods via a soundwalk and concluded they provide similar soundscape categorizations with strong statistical significance; however, according to their study, the correspondence was not perfect. Then, Mitchell et al. (2020) presented the Soundscape Indices (SSID) Protocol for urban soundscape surveys, based on the ISO standard but providing a concrete approach to the questionnaire instead of two alternatives. In order to maintain consistency with the on-going research, the SSID questionnaire was used as a reference for this study with a few modifications. Finally, the questionnaire created for the soundwalks in Detmold was organized in two parts: The first part included 10 questions for each area. Questions 1 to 9 were answered with a 1-5 scale regarding the identification of sound sources, perceptual attributes, surrounding sound environment, surrounding visual environment, appropriateness of surrounding sound environment, loudness, echo/reverberation, frequency of visits to the place and willingness to visit the area again. Question 10 was open-ended and optional. The second part of the questionnaire was filled out at the end of the walk and it included eight questions regarding the participant's mental and physical state, age, country of precedence, gender, occupational status, level of education and familiarity with the place.

2.3. Data analysis

The questionnaires provided quantitative data due to the 1-5 scales. The median values of each perceptual attribute (eventful, chaotic, monotonous, uneventful, calm, pleasant, and vibrant) were calculated with the formulas presented by ISO 12913-3:2019, "Analysis of data related to Method A" to find coordinates in a scatter plot characterizing each area, as proposed in the principal components model by Axelsson et al. (2010).

The coordinates for pleasantness P were calculated by means of Formula (A.1):

$$P = (p-a)+\cos 45°\cdot(ca-ch)+\cos 45°\cdot(v-m) \quad \text{(A.1)}$$

The coordinates for eventfulness E were calculated by means of Formula (A.2):

$$E = (e-u)+\cos 45°\cdot(ch-ca)+\cos 45°\cdot(v-m) \quad \text{(A.2)}$$

where:

a is annoying;
ca is calm;
ch is chaotic;
e is eventful;
m is monotonous;
p is pleasant;
u is uneventful;
v is vibrant.

3. Results

The first round of two simultaneous walks started around 10:00 am and was guided by two researchers, each carrying a tripod loaded with a sound level meter and an audio recorder. Group 1A followed Path #1 (areas 1 – 8) and group 2A followed Path #2 (areas 9 – 16). Then, around 11:30, group 1B followed Path #1 and group 2B followed Path #2. The first two groups walked and filled out the questionnaire without the sound of the construction site and the latter two groups walked during active construction work and additionally, there was music playing at the beer bar on campus.

The most notable changes in the results of Path #1, between groups 1A and 1B were that the perception of area 1 shifted from pleasant/vibrant towards chaotic/eventful. Area 2 went from monotonous to eventful/vibrant. Area 3 shifted from eventful towards more chaotic. Area 4 shifted from unpleasant/chaotic to eventful/vibrant. Area 5 and 6 shifted from vibrant to chaotic. Area 7 shifted from chaotic to closer to eventful. Area 8 was qualified as unpleasant/chaotic and it didn't change much, getting closer to chaotic (Figure 3). While these perceptual changes occurred, sound level measurements became higher in areas 1 to 6. In areas 7 and 8 the sound level measurement decreased slightly (Table 1).

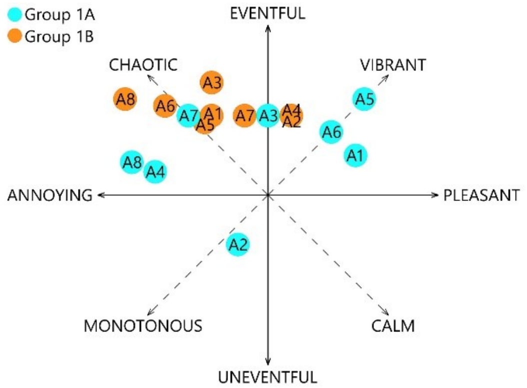
The most significant changes in Path #2, between groups 2A and 2B were that the perception of areas 9 to 11 shifted from calm/pleasant to eventful/chaotic.

Area 12 shifted from eventful/vibrant to eventful/chaotic. Area 13 shifted slightly from vibrant/pleasant to eventful/vibrant. Area 14 shifted from vibrant to eventful/chaotic. Area 15 shifted from eventful towards vibrant. Area 16 shifted from monotonous to uneventful/calm (Figure 4). While these perceptual changes occurred, the sound levels of all areas increased for group 2B (Table 2).

A scatter plot with the results of groups 1A and 1B is presented in Figure 3. Both groups visited the same 8 areas in Path #1, but group 1A visited them before the construction works or music started.

Figure 3

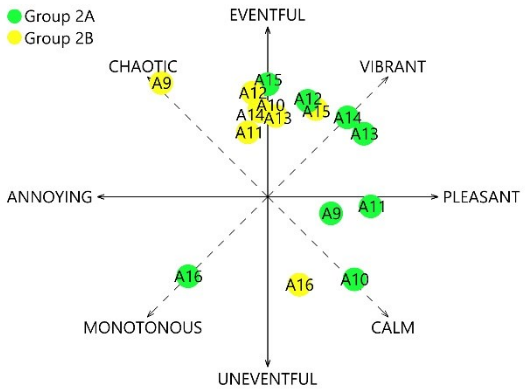
Characterization of the soundscape on Path #1. Group 1A and Group 1B.



Similarly, the results of groups 2A and 2B is presented in Figure 4. They visited areas 9 to 16, but group 1A visited them before the construction works or music started.

Figure 4

Characterization of the soundscape on Path #2. Group 2A and Group 2B.



During the soundwalk, continuous measurements of the sound pressure levels were carried out during each group's walk. Figure 5 shows measurements for each group in each area. A total of 32 measurements of dBA for three minutes. The average values for the three minutes that each group stayed in each area were calculated. Table 1 shows the averaged sound level of areas 1 to 8; Table 2 shows the average sound level in areas 9 to 16 for groups 2A and 2B.

Figure 5

Sound level measurements in dBA for each group.

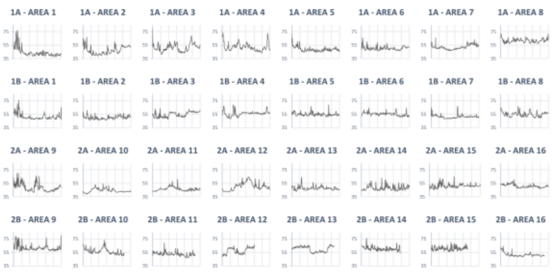


Table 1

The equivalent continuous sound level in dBA for each area in Path #1.

Path 1	A1	A2	A3	A4	A5	A6	A7	A8
1A	44,04	47,16	51,42	52,34	48,93	50,37	52,03	61,67
1B	51,34	50,01	54,78	56,13	54,76	55,36	51,35	54,97

Table 2

The equivalent continuous sound level in dBA for each area in Path #2.

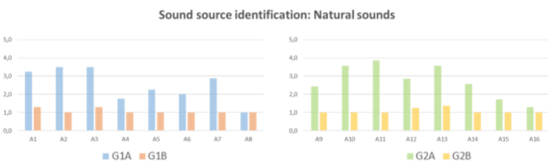
Path 2	A9	A10	A11	A12	A13	A14	A15	A16
2A	48,96	44,28	46,45	50,52	47,76	48,09	51,21	51,05
2B	61,73	56,85	52,47	57,62	60,09	60,58	60,66	51,73

4. Discussion

The results of the soundwalk at the campus showed how the context can influence people's experience of the acoustic environment in several ways. Firstly, as seen in figure 6, the questionnaire revealed that people who walked in the groups without construction noise or music (1A and 2A) perceived natural sounds such as birds or wind on trees, and the groups who went later (1B and 2B) didn't report natural sounds, however they reported other sounds such as construction noise or music.

Figure 6

Sound source identification: natural sounds.



Regarding the Kindergarten, the first group in area 2 reported the soundscape as annoying and monotonous, and the second group reported it as eventful, vibrant, and pleasant. This could likely indicate that without construction noise, sounds of children playing dominated the area and disturbed people, but in a context where there was loud construction noise, the kindergarten was perceived more positively.

Additionally, in the presence of other people and music around areas 14, 15 and 16, group 2B reported a lower perceived loudness than group 1B, however, the dBA levels were higher. This reveals that people's perception of loudness is not necessarily correlated to the measured sound levels. Finally, group 2A characterized area 16 as monotonous, but when there were construction works on the street, group 2B reported it to be calm.

The outcomes provide valuable new evidence on the factors influencing people's perception of the acoustic environment at the university campus and can inform stakeholders how to improve environmental quality. However, it is important to consider that this research was limited to the central area of the campus on a specific day; further data is required to test the significance of the factors affecting the soundscape. Future research is intended to follow previous work by Balderrama et al. (2022) in order to further study of the potential effects of façades on the acoustic environment and the soundscape with the aim to provide a better understanding of the relationship between the buildings, people's perception of sound and overall life quality in cities.

5. Conclusion

This research was conducted to study the soundscape on a typical university campus, taking the case of TH OWL in Detmold as an example. Two different paths with eight stops across the campus were planned, and a total of 30 people participated in a soundwalk. Questionnaires were used to survey people's perception of sound, and sound measurements were taken, along with photographs and videos to document the acoustic environment and the context. The data collected suggests that people's perception is susceptible to the context, as participants seemed to shift their perception according to activities that captured their attention, such as sound from nature, sounds from children playing, noise from a construction site, music playing and groups of students at the campus. The results provide insights about people's perception of the acoustic environment in relation to the context and give a reference of the soundscape at the university campus.

6. Acknowledgements

The authors would like to thank the people who voluntarily participated in the soundwalk on September 22nd, 2022.

7. References

Aletta, F. (2022). Listening to cities—From noisy environments to positive soundscapes. https://doi.org/10.13140/RG.2.2.21767.06566

Aletta, F., Guattari, C., Evangelisti, L., Asdrubali, F., Oberman, T., & Kang, J. (2019). Exploring the compatibility of "Method A" and "Method B" data collection protocols reported in the ISO/TS 12913-2:2018 for urban soundscape via a soundwalk. Applied Acoustics, 155, 190–203. https://doi.org/10.1016/j.apacoust.2019.05.024

Aletta, F., Kang, J., & Axelsson, Ö. (2016). Soundscape descriptors and a conceptual framework for developing predictive soundscape models. Landscape and Urban Planning, 149, 65–74. https://doi.org/10.1016/j.landurbplan.2016.02.001

Aletta, F., & Xiao, J. (2018). What are the Current Priorities and Challenges for (Urban) Soundscape Research? Challenges, 9(1), 16. https://doi.org/10.3390/challe9010016

Auernhammer, J., Zallio, M., Domingo, L., & Leifer, L. (2022). Facets of Human-Centered Design: The Evolution of Designing by, with, and for People. In C. Meinel & L. Leifer (Eds.), Design Thinking Research (pp. 227–245). Springer International Publishing. https://doi.org/10.1007/978-3-031-09297-8_12

Axelsson, Ö., Nilsson, M. E., & Berglund, B. (2010). A principal components model of soundscape perception. The Journal of the Acoustical Society of America, 128(5), 2836–2846. https://doi.org/10.1121/1.3493436

Balderrama, A., Kang, J., Prieto, A., Luna-Navarro, A., Arztmann, D., & Knaack, U. (2022). Effects of Façades on Urban Acoustic Environment and Soundscape: A Systematic Review. Sustainability, 14(15), 9670. https://doi.org/10.3390/su14159670

Environmental noise guidelines for European Region. (2018). WHO Regional Office for Europe.

European Environment Agency. (2014). Noise in Europe 2014. Publications Office. https://data.europa.eu/doi/10.2800/763331

International Organization for Standardization, ISO 12913-1:2014; Acoustics–Soundscape–Part 1: Definition and Conceptual Framework; International Organization for Standardization: Geneva, Switzerland, 2014.

International Organization for Standardization, ISO 12913-2:2018; Acoustics—Soundscape—Part 2: Data Collection and Reporting Requirements; International Organization for Standardization: Geneva, Switzerland, 2018.

International Organization for Standardization, ISO/TS 12913-3:2019, Acoustics—Soundscape—Part 3: Data Analysis; International Organization for Standardization: Geneva, Switzerland, 2019.

Kang, J. (2023). Soundscape in city and built environment: Current developments and design potentials. City and Built Environment, 1(1), 1. https://doi.org/10.1007/s44213-022-00005-6

Mancini, S., Mascolo, A., Graziuso, G., & Guarnaccia, C. (2021). Soundwalk, Questionnaires and Noise Measurements in a University Campus: A Soundscape Study. Sustainability, 13(2), 841. https://doi.org/10.3390/su13020841

Mitchell, A., Oberman, T., Aletta, F., Erfanian, M., Kachlicka, M., Lionello, M., & Kang, J. (2020). The Soundscape Indices (SSID) Protocol: A Method for Urban Soundscape Surveys—Questionnaires with Acoustical and Contextual Information. Applied Sciences, 10(7), 2397. https://doi.org/10.3390/app10072397

Schafer, R. M. (1969). The New Soundscape, Associated Music, New York, NY, pp. 1–65.

Schafer, R. M. (1977). The Soundscape: Our Sonic Environment and the Tuning of the World; Knopf: New York, NY, USA, 1977.

Southworth, M. The sonic environment of cities. Environ. Behav. 1969, 1, 49–70.

Theakston, F., & Weltgesundheitsorganisation (Eds.). (2011). Burden of disease from environmental noise: Quantification of healthy life years lost in Europe. World Health Organization, Regional Office for Europe.

United Nations (2015) Transforming our world: the 2030 Agenda for Sustainable Development https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf?OpenElement

Xiao, J., Aletta, F., & Ali-Maclachlan, I. (2022). On the Opportunities of the Soundscape Approach to Revitalise Acoustics Training in Undergraduate Architectural Courses. Sustainability, 14(4), 1957. https://doi.org/10.3390/su14041957

Yang, J., & Lu, H. (2022). Visualizing the Knowledge Domain in Urban Soundscape: A Scientometric Analysis Based on CiteSpace. International Journal of Environmental Research and Public Health, 19(21), 13912. https://doi.org/10.3390/ijerph192113912