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Application of ISO 12913 Standard to Assess Urban Soundscapes: A Case Study on Poznań

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ISO 12913 standards provide a unified framework for describing and assessing soundscapes, however, the lack of a Polish translation has so far limited their practical use. This paper presents the first application of a validated Polish version of the ISO/TS 12913-2 perceptual attributes, enabling full cross-language comparability of results. Whereas Polish research has traditionally focused on noise annoyance and broad judgements of acoustic comfort or discomfort, we outline the complete ISO-compliant assessment procedure, which combines: a soundwalk, questionnaires and audio-visual recording. The study was conducted at eight diverse urban locations in Poznań, Poland. Participants rated the soundscapes using eight attributes: *przyjemne*, *tętniące życiem*, *bogate w wydarzenia*, *chaotyczne*, *dokuczliwe*, *monotonne*, *ubogie w wydarzenia*, *spokojne*. Each rating set is mapped to a point in the 2D pleasantness-eventfulness space defined in ISO/TS 12913-3, facilitating visual comparison of locations and the identification of design needs. Results reveal pronounced perceptual differences between spatial typologies and demonstrate that the standardized approach provides richer, multidimensional information about the acoustic environment than conventional noise indicators. The proposed methodology establishes a reference framework for Polish soundscape studies and can support the creation of more people-friendly urban acoustic environments.

Keywords: soundscape, ISO 12913, Polish translation, soundwalk, perceptual attributes.

1. Introduction

International Organization for Standardization [ISO] 12913 standards provide a unified framework for describing and assessing soundscapes. Part 1 (ISO, 2014) defines the concept of a 'soundscape' and presents its conceptual model. Part 2 (ISO, 2018) specifies the requirements for data collection and reporting in soundscape studies, while part 3 (ISO, 2025) sets out methods for analyzing and interpreting those data. Method A in part 2 is a valuable source for acquiring quantitative data during soundwalks. The questionnaire permits a subjective evaluation of the perceived affective quality of the acoustic environment using eight attributes – pleasant, vibrant, eventful, chaotic, annoying, monotonous, and calm – on the five-point bipolar Likert scale. These attributes are embedded in the soundscape circumplex model (Axelsson *et al.*, 2010; ISO, 2025). In the ideal circumplex, adjacent attributes (i.e., pleasant–vibrant) are spaced 45° apart, whereas opposing ones (i.e., pleasant–annoying) are 180° apart (Fig. 1). From these eight attributes, the formulas in ISO/TS 12913-3 yield the indices pleasantness and eventfulness, which are displayed in a 2D eventfulness–pleasantness coordinate system (ISO, 2025; Mitchell *et al.*, 2022).

The Soundscape Attributes Translation Project (SATP) demonstrated that equal angular spacing between attributes is an idealized assumption and the angles depend strongly on the language in which the acoustic

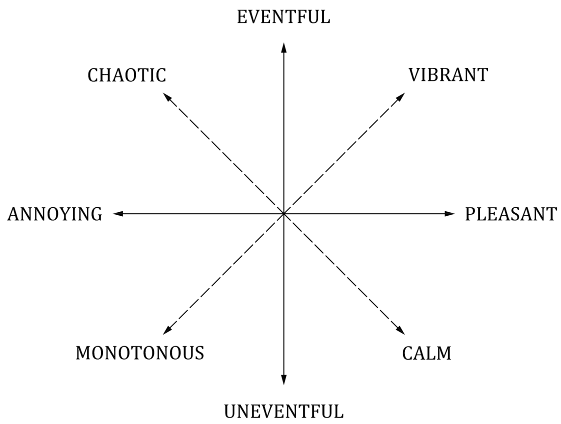

Fig. 1. Soundscape circumplex model adapted from Fig. A.1 of ISO/TS 12913-3:2025 (ISO, 2025).

environment is assessed (Aletta *et al.*, 2024). The project developed a protocol for validating translations of the ISO (2018) soundscape attributes, consisting of a headphone-based listening experiment and a four-step validation method employing various statistical analyses. Another outcome was the update of ISO/TS 12913-3 (2025), which now includes correction angles for 13 languages that successfully passed validation, to be applied when calculating pleasantness and eventfulness. This update ensures cross-lingual comparability of soundscape assessments.

Pleasantness (P_{ISO}) and eventfulness (E_{ISO}) coordinates are calculated (Aletta *et al.*, 2024; ISO, 2025) using:

$$P_{\text{ISO}} = \frac{1}{\lambda_P} \sum_{i=1}^{8} \cos(\theta_i) \cdot \xi_i, \tag{1}$$

$$E_{\text{ISO}} = \frac{1}{\lambda_E} \sum_{i=1}^{8} \sin(\theta_i) \cdot \xi_i, \tag{2}$$

where i indexes each circumplex scale, θ_i is the adjusted angle for the i-th soundscape attribute, and ξ_i is the value for that scale. The $1/\lambda$ provides a scaling factor to bring the range of P_{ISO}, E_{ISO} values to $[-1, +1]$:

$$\lambda_P = \frac{\rho}{2} \sum_{i=1}^{8} |\cos\theta_i|, \tag{3}$$

$$\lambda_E = \frac{\rho}{2} \sum_{i=1}^{8} |\sin\theta_i|, \tag{4}$$

where ρ is the range of the possible response values (i.e., $\rho = 5 - 1 = 4$ for the Likert scale, $\rho = 100$ for 0 to 100 scale responses).

2. Polish version of soundscape attributes

Until now, Polish psychoacoustic research has usually assessed soundscapes differently – by determining their annoyance, comfort or discomfort (Preis *et al.*, 2015; Szychowska *et al.*, 2018; Felcyn *et al.*, 2021). Although Polish studies using ISO 12913 exist (Młynarczyk, Wiciak, 2024), the manner in which the individual attributes were translated in their questionnaires is unclear. The lack of a Polish version of ISO 12913 created the need for a validated Polish version of the soundscape attributes. Consequently, we contacted the SATP leadership to join the project as researchers from Adam Mickiewicz University in Poznań. Through our participation, we developed a validated Polish attribute set – *przyjemne, tętniące życiem, bogate w wydarzenia, chaotyczne,* *dokuczliwe, monotonne, ubogie w wydarzenia, spokojne* (Dumanowski *et al.*, 2025) – and obtained the adjusted angles required to calculate pleasantness and eventfulness (Table 1). Thus, a methodology for proper soundscape assessment in the Polish language is now established.

Table 1. Polish translation of ISO (2018) soundscape attributes with obtained adjustment angles.

ISO (2018) soundscape attribute	ISO (2019) original angle [°]	Validated Polish translation	Obtained Polish adjustment angle [°]
Pleasant	0	Przyjemne	0
Vibrant	45	Tętniące życiem	69
Eventful	90	Bogate w wydarzenia	91
Chaotic	135	Chaotyczne	128
Annoying	180	Dokuczliwe	176
Monotonous	225	Monotonne	266
Uneventful	270	Ubogie w wydarzenia	274
Calm	315	Spokojne	339

It should be noted that the correction angles affect only the transformation of raw attribute assessments into the pleasantness–eventfulness circumplex and not the soundwalk procedure or the perceptual judgments. Pleasantness and eventfulness are calculated using language-specific correction angles to ensure cross-language and cross-cultural compatibility, while variations in angle values affect only the numerical positioning within the 2D space.

The subsequent sections of this paper present the procedure and results of the first pilot soundwalk employing the validated Polish attributes and the calculation of pleasantness and eventfulness using the Polish correction angles.

3. Methods

3.1. Soundwalk route

On 13 May 2025 a soundwalk was carried out in the center of Poznań, Poland, under dry, calm weather conditions (wind speed below 3 m/s, temperature 18.5 °C, relative humidity 38 %). The route comprised eight evaluation points (see Fig. 2) and ran from the Kaponiera Roundabout to the Chrobry Bridge. The first stop, P1, was the large, traffic-intensive Kaponiera Roundabout (*Rondo Kaponiera*); P2 was Mickiewicz Square (*Plac Mickiewicza*) on St. Martin Street; P3 led into Mickiewicz Park (*Park Mickiewicza*), a green space with a fountain on Fredro Street. P4, Freedom Square (*Plac Wolności*), is another central plaza with a fountain, while P5, Old Market Square (*Stary Rynek*), represents historical center of the city. From there the walk continued to P6,

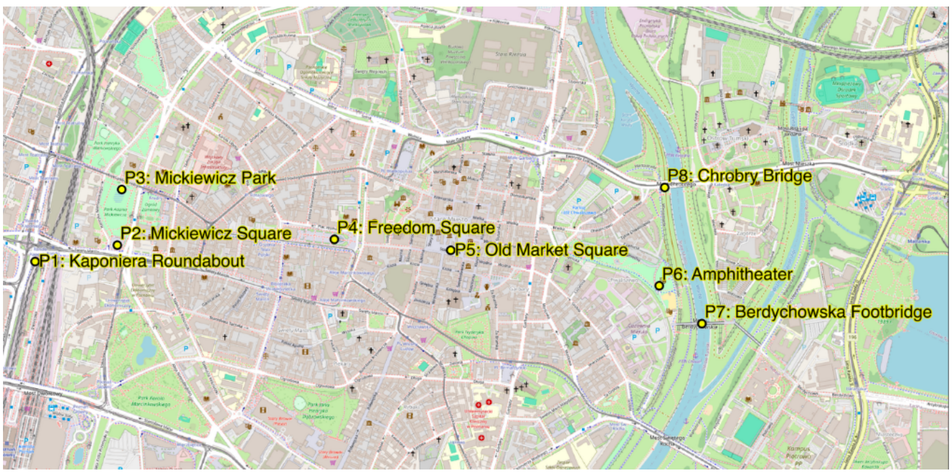

Fig. 2. Soundwalk points in Poznań on map derived from OpenStreetMap.

the Amphitheater (*Amfiteatr*) in the riverside park located next to the cultural-recreational KontenerART area, proceeded across P7, the Berdychowska Footbridge (*Kładka Berdychowska*) over the Warta River, and ended at P8, the Chrobry Bridge (*Most Chrobrego*), which spans the Warta River and links the heavily trafficked Estkowski Street and Wyszyński Street.

3.2. Participants

Thirteen participants (5 females, 8 males; age range 22 to 73 years; $M_{\text{age}} = 29$, $SD_{\text{age}} = 14.4$) took part in the soundwalk. The group consisted of acoustics students along with three lecturers from Adam Mickiewicz University.

3.3. Procedure

At each point the participants evaluated the soundscape using the Polish-language soundscape questionnaire translated from ISO (2018). The survey was hosted online: participants scanned a QR code that redirected them to a pre-prepared questionnaire created using the FreeOnlineSurveys. Within the form (Fig. 3) they identified audible sound sources, rated the eight soundscape attributes and could enter free comments. All ratings were given on interactive sliders ranging from 0 to 100. The structure of our questionnaire was inspired by the survey used in the article by Mitchell *et al.* (2020).

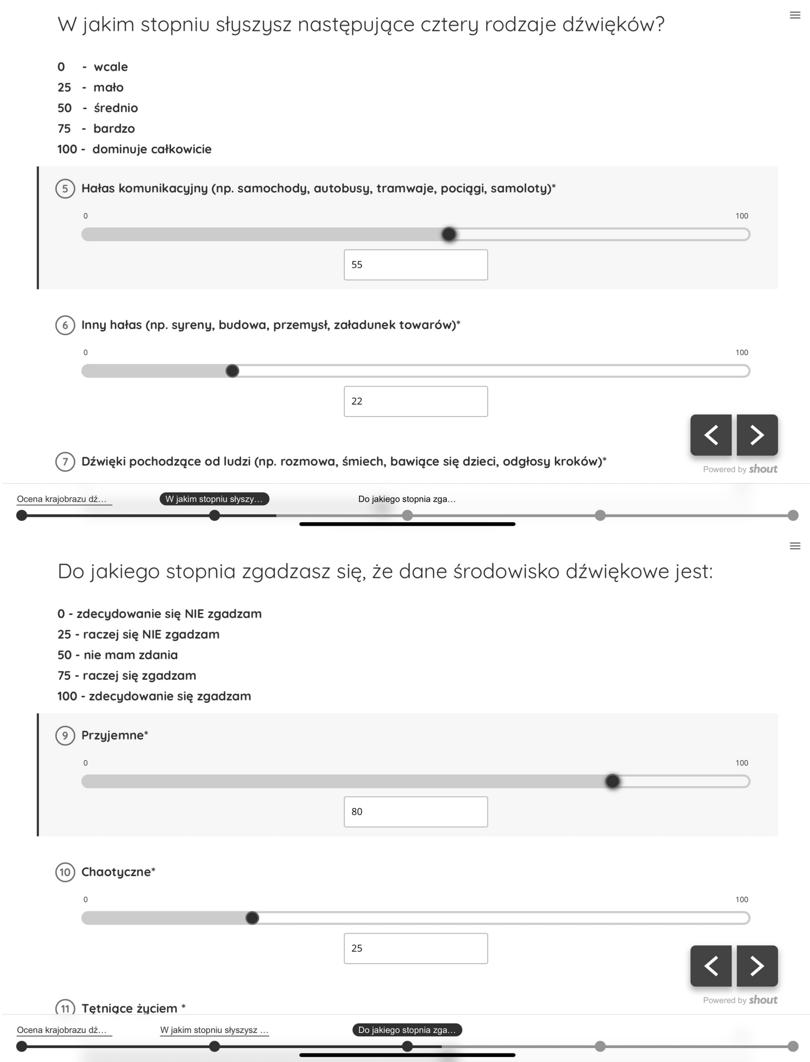

Fig. 3. Screenshots of the graphical user interface for evaluating soundscape using FreeOnlineSurveys.

For sound-source identification the question read: 'To what extent do you presently hear the following four types of sounds? (0 – not at all, 100 – dominates completely).' The four categories presented were: traffic noise (e.g., cars, buses, trams, trains, airplanes), other noise (e.g., sirens, construction work, industrial activity, loading of goods), human sounds (e.g., conversation, laughter, children playing, footsteps), and natural sounds (e.g., birdsong, flowing water, wind in vegetation).

For the attribute assessment (pleasant, vibrant, eventful, chaotic, annoying, monotonous, uneventful, calm) it read: 'To what extent do you agree or disagree that the present surrounding sound environment is...? (0 – strongly disagree, 100 – strongly agree).' The soundscape evaluation at each location lasted approximately 5 min.

While the questionnaire was being completed, binaural audio, ambisonic audio and 360° video were recorded simultaneously (see Fig. 4 for the recording setup). A calibrated recording device (HEAD acoustics, SQuadriga II – Mobile recording and playback system) with binaural microphones (HEAD acoustics, BHS II – Binaural Headset for Aurally Accurate Recording and Playback) was used, enabling subsequent extraction of equivalent sound levels and psychoacoustic parameters from the recorded samples. The visual environment was captured using a 360° camera (GoPro MAX 360 Action Camera), while ambisonic audio was recorded using the first-order ambisonic microphone (RØDE NT-SF1 Ambionic Microphone) with a multichannel audio recorder (Zoom F6 Field Recorder).

Fig. 4. Recording setup – binaural microphones, ambisonic microphone, and 360° video camera.

4. Results

4.1. Participants' subjective soundscape evaluations

Based on the ratings of the eight soundscape attributes, the indices pleasantness and eventfulness were computed using Eq. (1) to Eq. (4). Figure 5 plots every single assessment (all participants at all eight points) to illustrate the spread across the 2D eventfulness–pleasantness space. Figure 6 shows the individual eventfulness–pleasantness ratings for the eight Poznań locations made by the 13 soundwalk participants, together with the median value for each site. Kernel-density contours representing the 10th, 25th, 50th, and 75th percentiles are superimposed to visualize the concentration of responses. Figure 7 presents the mean perceived prominence of the four predefined sound-source categories at each location; error bars indicate the 95 % confidence intervals.

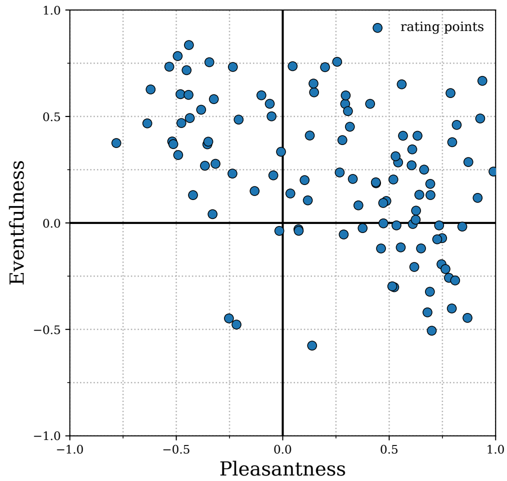

Fig. 5. All participants' ratings at all eight locations mapped onto eventfulness–pleasantness coordinate system.

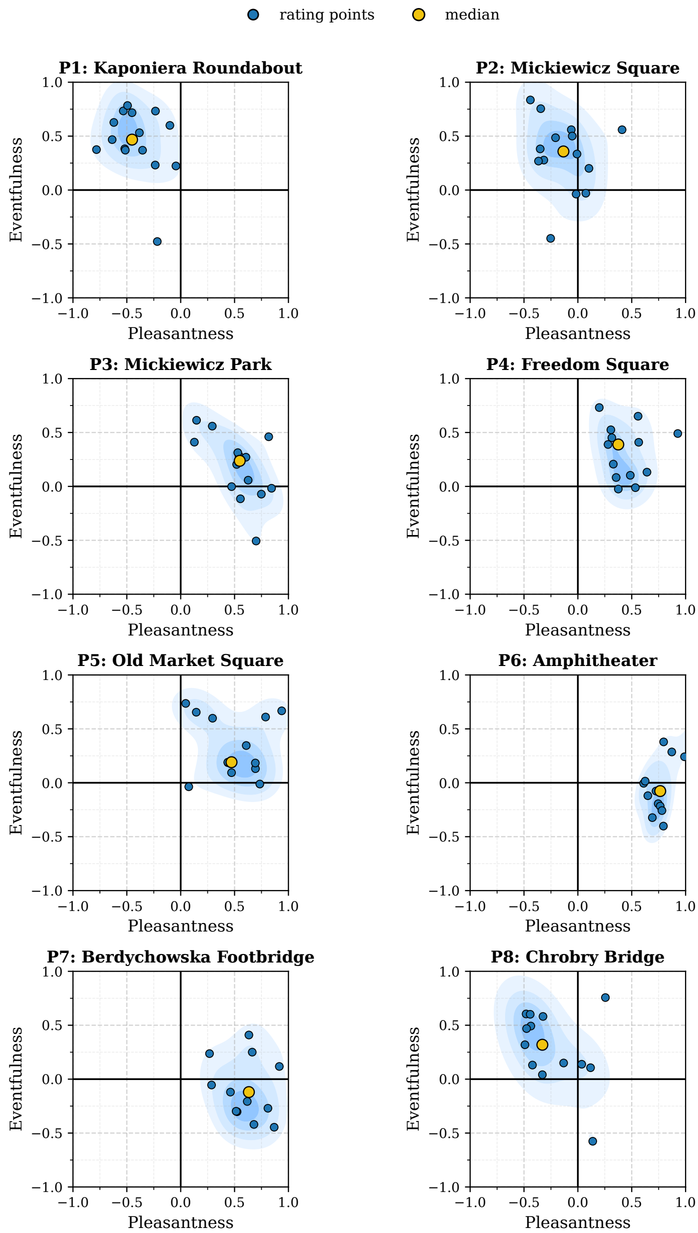

Fig. 6. Eventfulness–pleasantness ratings for each of the eight locations in Poznań.

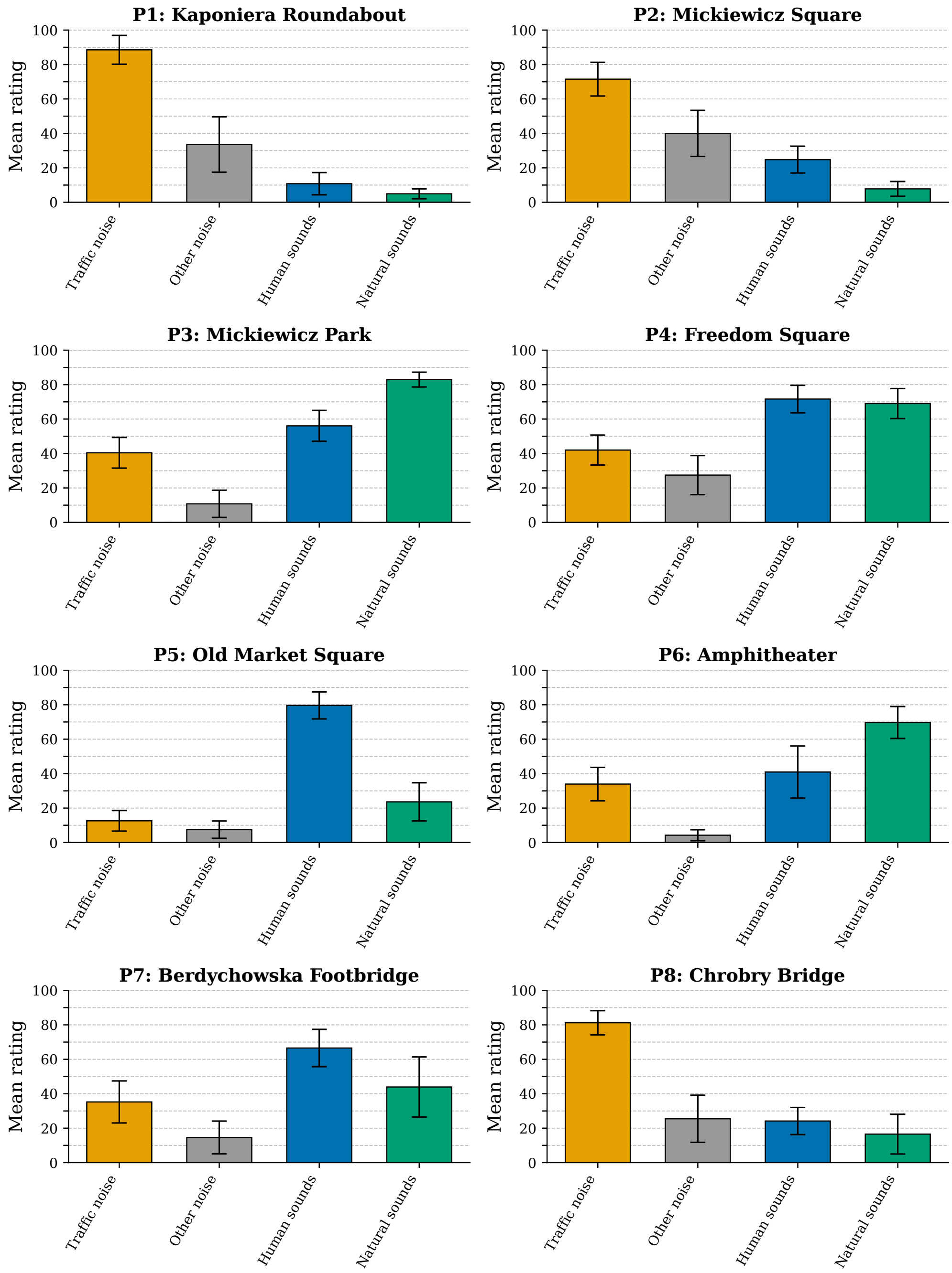

FIG. 7. Mean value of perceived prominence of the four predefined sound-source categories at each location.

4.2. Objective parameters calculated from binaural recordings

In accordance with the requirements of ISO (2019), objective acoustical parameters – equivalent sound level (L_{Aeq}), loudness, N5, N95, sharpness, fluctuation strength, roughness and tonality – were extracted from approximately five-minute binaural recordings at each of the eight measurement points using standard-compliant sound analysis software (HEAD acoustics, ArtemiS SUITE Software (Datasheet)). Because binaural recordings provide separate left- and right-ear channels, the channels were processed individually. In line with the standard, the higher of the two values was retained for every descriptor. The values of all calculated objective parameters are listed in Table 2. A visual representation of this data is shown in Fig. 8.

TABLE 2. Objective parameters of eight evaluated locations, calculated from binaural recordings.

Location	P1: Kaponiera Roundabout	P2: Mickiewicz Square	P3: Mickiewicz Park	P4: Freedom Square	P5: Old Market Square	P6: Amphitheater	P7: Berdychowska Footbridge	P8: Chrobry Bridge
L_{Aeq} [dB]	85.9	66.9	68.3	59.1	61.8	53.8	55.8	72.3
Loudness [sone]	53.8	24.4	24.7	15.2	16.4	10.0	11.3	29.6
N5 [sone]	45.1	25.9	26.9	18.4	16.2	10.7	13.8	35.7
N95 [sone]	12.5	13.9	21.2	11.4	10.2	5.2	5.2	11.6
Sharpness [acum]	2.45	2.02	3.94	2.60	2.15	1.69	1.80	2.44
Fluctuation strength [vacil]	0.08	0.05	0.01	0.01	0.02	0.01	0.02	0.01
Roughness [asper]	0.04	0.05	0.03	0.02	0.03	0.02	0.03	0.04
Tonality [tuHMS]	0.21	0.26	0.14	0.16	0.18	0.17	0.15	0.16

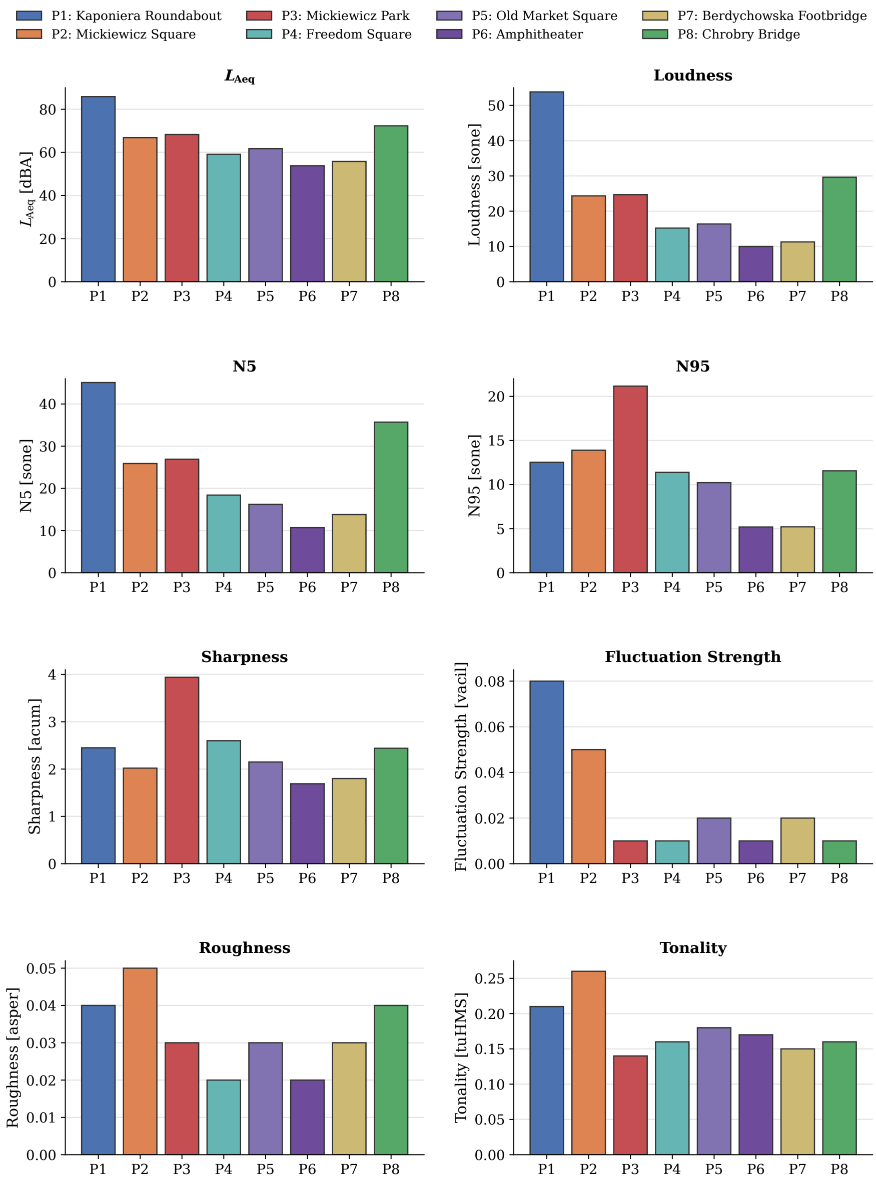

FIG. 8. Objective parameters across eight evaluated locations.

P1: Kaponiera Roundabout shows the highest values of L_{Aeq}, loudness, N5, and fluctuation strength, as well as the highest median eventfulness, while recording the lowest median Pleasantness. P3: Mickiewicz Park has the greatest background loudness (N95) and the highest sharpness value, and its soundscape contains the largest share of natural sounds. At P2: Mickiewicz Square, traffic noise dominates, yet among all eight sites this square also contains the highest proportion of 'other' noises; it exhibits the greatest roughness and tonality. At P5: Old Market Square, human sounds represent the largest share of the soundscape. The most favorable soundscape is found in P6: Amphitheater, where L_{Aeq}, loudness, N5, N95, sharpness, and roughness reach their lowest values, and pleasantness is the highest of all locations. The lowest median Eventfulness is observed on P7: Berdychowska Footbridge.

5. Discussion

The individual-level data reveal a considerable spread, an expected consequence of the subjective nature of the ratings. One way to tighten the dispersion could be to inform participants in advance how to interpret each soundscape attribute; however, such instruction could introduce response bias. Although ISO/TS 12913-2 recommends a minimum of 20 respondents, the present study was conceived as a pilot intended to test the in-situ applicability of the Polish attribute set.

All judgments were made on a continuous 0–100 slider rather than on the five-point Likert scale suggested by ISO (2018). The finer 101-point resolution offers greater numerical precision when computing pleasantness and eventfulness. While this would be impractical with paper forms, the online survey interface made the slider implementation straightforward. A future experiment could explicitly compare the 0–100 slider with the five-step Likert format.

A few participants scored eventfulness markedly differently from the majority, possibly because the Polish terms 'bogate w wydarzenia' and 'ubogie w wydarzenia' were misunderstood, or because momentary lapses of attention led to reversed ratings.

As expected, soundscapes dominated by traffic noise received lower pleasantness scores than those characterized by human voices or natural sounds, confirming earlier findings (Nilsson, Berglund, 2006; Nilsson *et al.*, 2007; Axelsson *et al.*, 2010). According to Schafer's (1993) typology, the sites studied can be classified as hi-fi environments (P3: Mickiewicz Park, P4: Freedom Square, P5: Old Market Square, P6: Amphitheater, P7: Berdychowska Footbridge) and lo-fi environments (P1: Kaponiera Roundabout, P2: Mickiewicz Square, P8: Chrobry Bridge). In general, high L_{Aeq} and high loudness are associated with low pleasantness, whereas low values of these measures coincide with high pleasantness. This relationship is clear in very quiet and very loud contexts, where N5, loudness, and L_{Aeq} are good predictors of the pleasantness. In the mid-range of sound levels, the pattern weakens and exceptions emerge. For instance, P3: Mickiewicz Park was rated more pleasant than P2: Mickiewicz Square even though it showed higher L_{Aeq}, loudness, N5, N95, and sharpness, probably due to the fountain's masking effect and the presence of human voices and natural sounds. In contrast to level-related metrics, parameters describing temporal and tonal sound characteristics, such as fluctuation strength, sharpness, roughness, and tonality, were not significantly associated with either pleasantness or eventfulness.

These results indicate that sound level alone is insufficient to predict soundscape quality. They support the view that 'informational properties of soundscapes (i.e., categories of sounds) are better predictors of perceived soundscape quality than acoustic measures such as L_{Aeq}' (Axelsson *et al.*, 2010; Nilsson, 2007).

6. Conclusions

The study presented an evaluation of eight locations in Poznań during a pilot soundwalk conducted in accordance with ISO (2018), using the validated Polish version of the soundscape attributes. The proposed methodology establishes a reference framework for Polish soundscape studies and can guide the design of more people-friendly urban acoustic environments. Future work should recruit a larger and more diverse participant pool (beyond individuals linked to acoustics) and include sites that are monotonous. Follow-up studies might also apply the soundscape assessment protocol in laboratory settings to complement the in-situ findings.

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Conflict of interest

The authors declare that there are no known competing financial interests or personal relationships that could have influenced the work described in this paper.

Authors' contributions

Jakub Dumanowski conceptualized the study, wrote the original draft, prepared the surveys and the sound walk, developed the methodology, curated the data, performed the analysis, and created the visualizations. Anna Preis developed the methodology, prepared and supervised the sound walk, and conceptualized the study. Jan Felcyn performed the analysis, curated the data, and contributed to data interpretation. All authors reviewed and approved the final manuscript.

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