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

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ABSTRACT:

The International Organization for Standardization (ISO) recently released technical specifications about minimum reporting requirements in soundscape studies and methods for data collection (ISO/TS 12913-2:2018). The document provides an informative annex with three alternative methods: two are based on soundwalks and questionnaires, whilst the third refers to narrative interviews. This study was conducted in accordance with the ISO/TS 12913-2 technical specifications. Its aim was testing whether compatible results could be obtained from the first two methods, during the same data collection session. For this purpose, a soundwalk was organised in a university campus with two groups of students using the two methods separately, while experiencing the same acoustic environments. Results show that for this case study the two methods returned soundscape categorisations that are similar and have strong statistically significant associations (p = .023). In particular, in 7 out of 8 locations, the two methods would categorise positive and negative soundscapes identically. However, since the correspondence was not perfect, further studies should investigate the topic of methodological comparisons in soundscape research, and possibly consider revising or integrating the two methods.

Keywords: ISO 12913-1:2014, ISO/TS 12913-2:2018, soundscape, soundwalks, semantic scales, binaural recordings

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1. INTRODUCTION

Soundscape research has been growing steadily over the past decades. Originally rooted in the acoustic ecology and urban design theories of early authors of the topic, like Southworth and Schafer (Southworth, 1969; Schafer, 1977), the discipline rapidly expanded to cover a broader spectrum of research fields, ranging from the social, to the natural and engineering sciences (Kang, et al., 2016). Soundscape is gaining momentum in recent years, due to increasing pressure from society and community stakeholders to overcome a reactive approach to the management of the (urban) acoustic environments based merely on noise control policies (Brown, 2012; Asdrubali, 2014; Kang, 2017; Kang & Aletta, 2018), and to engage instead in a proactive way to promote acoustic environments that can support health and well-being (Andringa, et al., 2013; Lercher, van Kamp, von Lindern, & Botteldooren, 2015; Aletta, Oberman, & Kang, 2018; Bild, Pfeffer, Coler, Rubin, & Bertolini, 2018). This is reflected both in the academic context where the number of soundscape-related scientific publications is increasing constantly (Kang, et al., 2016; Kang & Aletta, 2018), and at a societal level as a growing number of policy documents, guidelines, and recommendations issued by international bodies and agencies make reference to the soundscape approach (European Parliament and Council, 2002; COST TUD Action TD-0804, 2013; European Environment Agency, 2014).

1.1. Soundscape standardization: general context

The soundscape researchers and practitioners' community committed to a standardization process for this emerging research field (Brown, Kang, & Gjestland, 2011). Among other initiatives, this resulted in a Working Group of the International Organization for Standardization (ISO), WG54 ISO/TC 43/SC 1, being established in 2008 with the purpose of harmonizing definitions, as well as methods for data collection about the individual responses to the acoustic environments and subsequent data analysis and interpretation (Axelsson, 2011). In 2014, the Part 1 of the ISO standard was released, where soundscape is defined as an "acoustic environment as perceived or experienced and/or understood by a person or people, in context" (International Organization for Standardization, 2014). Thus, soundscape is formally acknowledged as a different concept from acoustic environment, being substantially a perceptual construct.

The work of WG54 ISO/TC 43/SC 1 proceeded onto the more methodological part, addressing minimum reporting requirements in soundscape studies and methods for data collection. How to better "measure soundscape" (i.e., to gather individual responses to the experience of an acoustic environment) is a topic that has been long debated over the past years. There has not always been a clear consensus on the matter, as several different methods have been used for this purpose (for a review of methods, see for instance: Aletta, Kang, & Axelsson, 2016; Engel, Fiebig, Pfaffenbach, & Fels, 2018). Aletta et al. (2016) proposed a classification of soundscape data collection methods based on whether the acoustic environment is experienced on site, reproduced, or recalled in memory. Engel et al. (2018) recently reviewed the methods for soundscape data collection for 52 peer-reviewed papers published over the past 20 years. Similarly to Aletta et al., the authors concluded that the studies tend to rely on recurring methods; namely: soundwalks, interviews, listening tests, and focus groups. This is in line with previous studies that had also provided a more qualitative overview of typical methodological approaches in soundscape research (e.g., Aletta, Kang, & Axelsson, 2016). In particular, Engel and colleagues pointed out that the aspects considered during the soundwalks are also quite common and generally refer to "soundscape quality, sound sources evaluation, dominance, background, satisfaction and sound sources identification" (Engel, Fiebig, Pfaffenbach, & Fels, 2018). Yet, a great variety of methods exists and researchers have been inclined to use different tools. This is also reflected in a vibrant debate about what the more suitable methods for measuring soundscape data are, which led, for instance, to the initial lack of consensus to approve the Part 2 of the planned ISO standard during the summer of 2017 (International Organization for Standardization, 2017). However, the soundscape community does perceive the need for standardized tools to make the discipline more rigorous and applicable in real life (and design) scenarios (Aletta & Xiao, 2018), and Part 2 was eventually approved by the ISO Working Group in the form of "Technical specifications" (International Organization for Standardization, 2018).

1.2. The ISO/TS 12913-2:2018

This soundscape investigation adopts the definitions and general conceptual framework proposed in the ISO 12913-1:2014 standard (International Organization for Standardization, 2014) and was performed in accordance with ISO/TS 12913-2:2018 (International Organization for Standardization, 2018). In particular, the Annex C of the ISO/TS 12913-2:2018 suggest three possible protocols (Methods A, B, and C) for soundscape data collection. The Method A (Section C.3.1 of the ISO/TS 12913-2:2018) and the Method B (Section C.3.2 of the ISO/TS 12913-2:2018) propose two alternative questionnaires to be used during a soundwalk. The Method C (Section C.3.3 of the ISO/TS 12913-2:2018) instead proposes a general protocol for conducting narrative interviews, which typically take place off-site and aim at gathering more qualitative data and deepen the experts' understanding of the context. All these methods are relatively well-established in soundscape literature and have been used for a number of years before the publication of the technical specifications (see, for instance: Schulte-Fortkamp & Fiebig, 2006; Axelsson, Nilsson, & Berglund, 2009; Axelsson, Nilsson, & Berglund, 2010; COST TUD Action TD-0804, 2013; Jeon, et al., 2018). While the three methods are presented as being all possible options, they act at different layers. In particular, Method C is supposed to be used as an exploratory tool mainly for off-site investigations, it is mainly targeted for residents who are familiar with the soundscapes of the areas being investigated and consequently adopts a larger temporal framework and relates to soundscape being "recalled in memory". On the other hand, the Methods A and B deal with soundscape assessments being made on site (i.e., "right here, right now") and address substantially similar perceptual constructs and elements of the acoustic environment.

Figure 1 proposes a schematic representation of the ISO/TS 12913:2-2018 contents, with its Sections and Annexes. Sections 1-4 of the Technical Specifications provide an overview of

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the scope and context of the technical specifications, whilst sections 5 and 6 cover a general description of data collection methods (both individual responses and acoustic measurements) and reporting requirements. The technical specifications are then “operationalised” via a set of normative and informative annexes (A-E). The focus of the present study is on the comparison and compatibility of the protocols of Method A and B; indeed, as long as these two are presented in the technical specifications as mutually exclusive alternatives and the choice of the protocol lies with the researcher(s)/practitioner(s) leading the data collection campaign, one would expect the outcomes of the assessments not to vary substantially depending on the protocols used. Researchers have previously questioned whether using the same questionnaires/items and only changing the scales of assessment (e.g., from a five-point to a seven-point Likert scale) would return consistent results, and whether the same protocols would return consistent results over time in longitudinal studies. For instance, Fiebig (2018) observed that different scales (e.g. continuous/discrete) used to measure simple soundscape attributes (e.g., unpleasant/pleasant) would correlate significantly, suggesting that similar data could be gathered by using different scales. Likewise, in terms of repeatability over time, Fiebig and Herweg (2017) observed that, for the same attributes, using a 5-point Likert scale during soundwalks repeated over the years would result in a statistically significant similarity between the assessments of the sites, suggesting that the same tool individually would return consistent results over time. However, specific studies on the comparison and compatibility of Methods A and B of the technical specifications have not been conducted so far.

The topic is of utmost importance for the soundscape community, particularly because, if the methods for data collection and reporting requirements have been defined to some extent, the guidelines for the statistical analysis approach to use for such data have not been clarified yet. The Part 3 of the soundscape ISO 12913 standard series, which is currently under development, will hopefully offer further insights into specific techniques for data analysis (International Organization for Standardization, 2018).

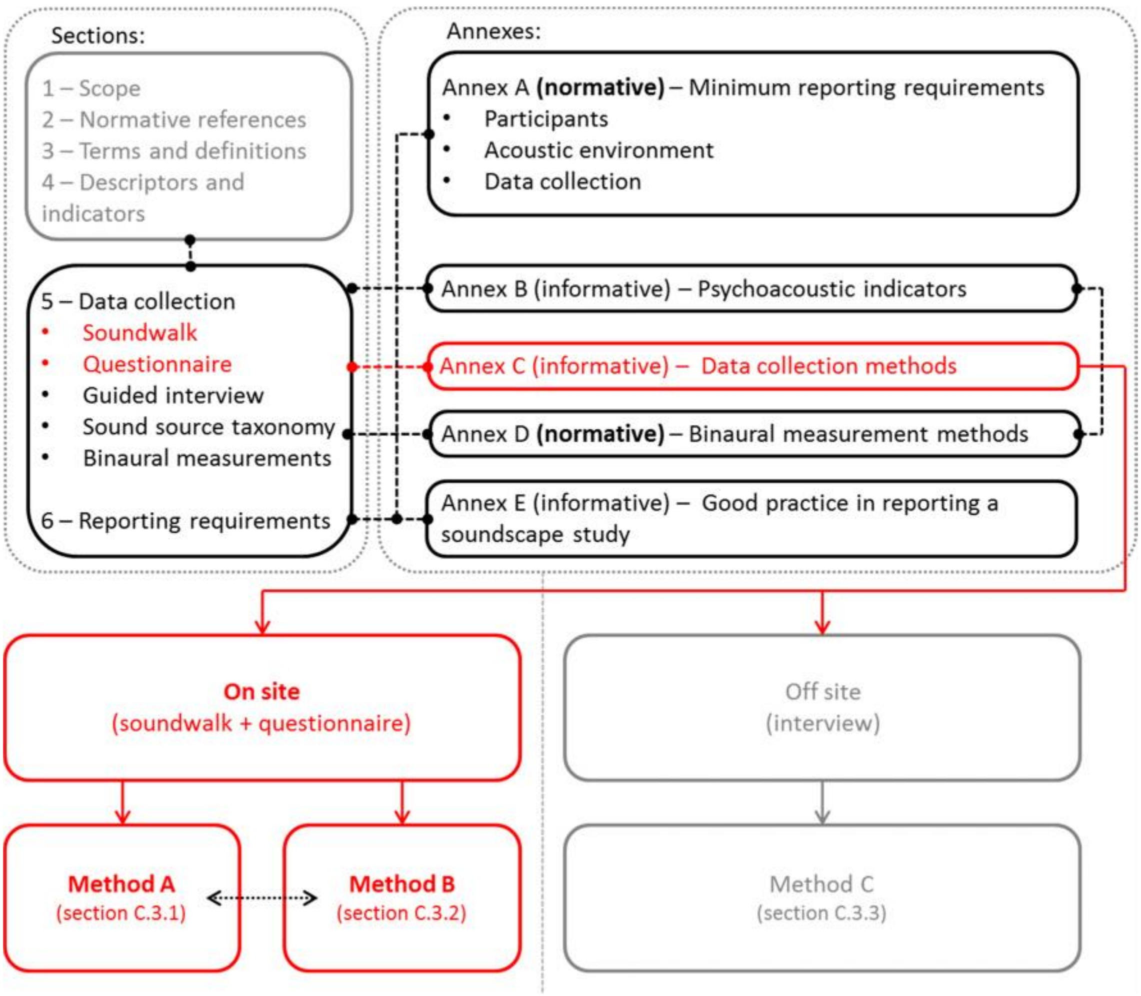

Figure 1 - Schematic outline of the ISO/TS 12913:2-2018. Numbers represent Sections of the document (top left box), while letters represent Annexes (top right box). The focus of the research conducted in the context of this study is highlighted in red

1.3. Objectives

The goal for which international standards are typically developed is offering researchers and practitioners operational tools to measure the reality around us and being able to make comparisons among measures taken in different contexts, in different moments, and by different surveyors. As mentioned before, the ISO/TS 12913-2:2018 propose instead a set of alternatives. In this study we focus on the protocols proposed for (urban) soundwalks (namely, Method A and Method B), since these are most commonly used in soundscape studies. Method C would not be applicable in this case as it relates to narrative interviews, typically conducted off-site and mostly in residential contexts. Data gathered through each method as a whole cannot be compared directly with the other, as only a few items correspond across protocols in terms of meaning/label of the perceptual attribute, structure of the question and scale of assessment. For this reason a different approach was sought, aiming at checking "compatibility" rather than direct "comparability" of the outcomes. The aim of this paper was indeed testing whether compatible results would be returned by the protocols of Method A and B. In the context of this research we refer to compatibility considering a general dichotomous valence assessment of "positive" (i.e., supportive) and "negative" (i.e., disruptive) soundscapes. The question was then whether the two protocols would lead to a categorisation of the data collection sites into same (or at least similar) groups of positive and negative soundscapes. For this purpose, a soundwalk was organised, using a university campus as case study, where two independent groups of participants assessed the same acoustic environments with the two methods.

Furthermore, for the items across the protocols that do correspond, a correlation analysis was performed to confirm findings from previous studies in the literature (Fiebig & Herweg, 2017; Fiebig, 2018). Finally, this work also aims at characterising the soundscape of the investigated site in accordance with the technical specifications.

The paper is structured as follows: Section 2 provides a description of the case study and addresses the methodological approach adopted in the research, describing the measurements and the procedure to statistically compare the results returned by the two questionnaires of Method A and Method B. Section 3 compares statistically the results obtained through the two methods, based on characterisation of the acoustic environment as recorded and experienced, both physically and perceptually, in accordance with the technical specifications. In Section 4 the main implications of the study are discussed and the conclusions are drawn in Section 5.

2. METHODS

This research is conducted in compliance with the ISO/TS 12913-2:2018 and it addressed the topic of results compatibility between the two protocols recommended in the informative annexes of the soundscape ISO technical specifications. In particular it covers the Annexes A-E of the technical specifications, by describing the case study area, the sample of participants, the protocol for gathering individual responses and the binaural recordings of the investigated acoustic environments. As a general method, this study relied on a soundwalk: this is a typical method for data collection in soundscape studies (Semidor, 2006; Jeon, Hong, & Lee, 2013; Aletta & Kang, 2015; D'Alessandro, Evangelisti, Guattari, Grazieschi, & Orsini, 2018) and is referred in Section 5 of the ISO technical specification as the approach to adopt when using either the Method A or the Method B of the Annex C (International Organization for Standardization, 2018). Considering the exploratory nature of this work, it was decided to use a university campus as case study, since these kinds of environments typically provide a varied (and yet, relatively controlled) acoustic environment where a broad range of sound sources are likely to be experienced (Trombetta Zannin, Engel, Kirrian Fiedler, & Bunn, 2013); for this reason the soundscape of university campus have also been receiving increasing research attention lately (Asdrubali, et al., 2017; D'Alessandro, Evangelisti, Guattari, Grazieschi, & Orsini, 2018).

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2.1. Case study

The investigated area is the outdoor space of the Engineering Department of Roma TRE University, located in the southern part of Rome and surrounded by main and secondary roads, characterized by high and low traffic flows, respectively (Figure 1a). The survey area is about 73,000 m^2. The Department spaces are spread over a number of buildings where offices, laboratories and university classrooms are located. Its outdoor space features green areas, common parts with gazebos and benches where students rest, access areas for services and three parking areas. Figure 2a shows the overall urban context of the campus, while Figure 2b shows the aerial view of the Engineering Department. Table 1 lists the locations ID and a brief description of the evaluation points and Figure 3 reports pictures of the eight locations selected for the soundwalk.

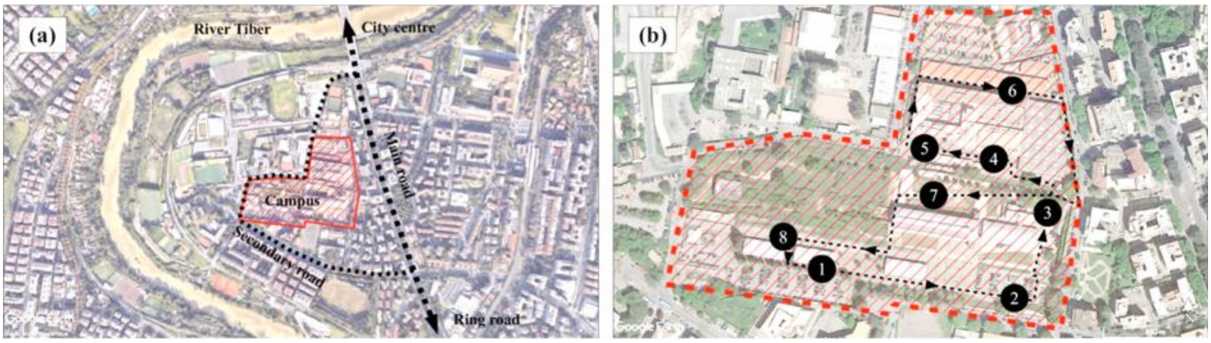

Figure 2 - Campus aerial view with the main and secondary roads (a); soundwalk path and locations (b). The red line indicates the boundary of the campus. The black dashed-line in (b) shows the sound walk while the arrows define the walking direction. The progressive numbers (from 1 to 8) identify the location points where binaural recordings and questionnaires were carried out

Table 1 - Measurements points description

Location ID	Description
1	Area outside the university classrooms building
2	Academic staff parking area
3	Green area at the entrance of the Department
4	Area between classrooms and a building where the central air conditioning and ventilation units are located
5	Secondary entrance of the Department
6	Area between entrance to the classroom and the university canteen
7	Green area equipped with benches and gazebos
8	Area between unused green area and classrooms building

This site was selected because it represents a delimited area, frequented by people of a similar age, who use the area every day, throughout the year, with the same purpose. The sound environment of the engineering campus was considered to be characterized by a relatively wide variety of sound source types, (natural sounds, human voices, traffic and sounds related to ventilation units).

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Figure 3 – The eight locations of the soundwalk. Pictures have not been taken during the performed soundwalk but at a later time, so they might not reflect environmental conditions present during the soundwalk

2.2. Procedure and questionnaires

Thirty-eight undergraduates, postgraduates and staff members at the Roma Tre University, 21 to 34 years old, took part in the soundwalk (10 women, 28 men; M_{age} = 24.7 years, SD = 3.1). Participants took part voluntarily; the students received university credits towards the "Sustainability and Environmental Impact Assessment" module. All participants provided informed consent, and the study was performed in accordance with the ethical requirements of the Declaration of Helsinki. Participants were invited to take part to a soundwalk via an email list of students and staff members of the Department of Engineering at Roma Tre University. Two days before the soundwalk a one-hour informative session and lecture took place at the University with the participants who had confirmed attendance, so that the main soundscape concepts and definitions could be introduced by the researchers and all participants had a common understanding of the items of the questionnaire and meaning of the soundscape attributes. The day of the soundwalk, a further brief training session took place before data collection started so that participants were familiar with the items of the protocols. After providing informed consent to take part in the soundwalk, participants were randomly sorted into two groups, namely Group A (n = 19) and Group B (n = 19) and assigned to the questionnaires of Method A (Section C.3.1 of the ISO/TS 12913-2:2018) and Method B (Section C.3.2 of the ISO/TS 12913-2:2018) accordingly. The two questionnaires are reported in Table 2 and Table 3. The questionnaires were translated to Italian, as reported in Annex 1 of this paper. There is still no official Italian version of the questionnaire provided by the ISO Working Group, so a translation that was as accurate as possible was achieved via an informal focus group previously carried out by the authors, being informed by some references already published in Italian soundscape literature (e.g., Brambilla, Masullo, Pascale, & Sorrentino, 2016; Brambilla, Masullo, & Pedrielli, 2018). Official translations are not yet available and some researchers have faced similar issues in other languages (e.g., Tarlao, Steele, Fernandez, & Guastavino, 2016; Jeon, et al., 2018).

The two groups of participants were led by an experimenter who walked across the study area and stopped at the eight selected locations reported in Table 1. As previously mentioned, Figure 1b shows the route of the soundwalk; participants were instructed to remain silent during the whole data collection session. For each location, participants were required to listen to the acoustic environment for two minutes and to fill in the questionnaire of Method A or Method B, depending on their group. For descriptive purposes, the questionnaire also included questions about age and gender.

The technical specifications recommend having relatively small groups to attend a soundwalk, and this can be observed also in several soundscape studies (Dokmeci, et al., 2012; Jeon, Hong, & Lee, 2013; Aletta & Kang, 2015). However, the rationale for having a slightly bigger number of participants during the session was making sure that both groups A and B would be exposed exactly to the same conditions, and thus be able to assess the same acoustic environments, so that the effect of the questionnaire could be explored, while preserving a reasonable number of respondents for each method. Having multiple sessions separately with smaller groups would have indeed jeopardised the possibility to achieve the main aim of this study.

Table 2 - Questionnaire used for the participants of Group A of the soundwalk (Method A of the ISO/TS 12913-2:2018)

Category	Question	Item(s)	Scale/Response Type
Sound sources	To what extent do you presently hear the four following types of sounds?	• Traffic noise (e.g., cars, buses, trains, airplanes) • Other noise (e.g., sirens, construction, industry, loading of goods) • Sounds from human beings (e.g., conversation, laughter, children at play, footsteps) • Natural sounds (e.g., singing birds, flowing water, wind in vegetation)	Not at all (1); A little (2); Moderately (3); A lot (4); Dominates completely (5)
Perceived affective quality	For each of the 8 scales below, to what extent do you agree or disagree that the present surrounding sound environment is…	• Pleasant • Chaotic • Vibrant • Uneventful • Calm • Annoying • Eventful • Monotonous	Strongly agree (1); Agree (2); Neither agree, nor disagree (3); Disagree (4); Strongly disagree (5)
Overall quality	Overall, how would you describe the present surrounding sound environment?	–	Very good (1); Good (2); Neither good, nor bad (3); Bad (4); Very bad (5)
	Overall, to what extent is the present surrounding sound environment appropriate to the present place?	–	Not at all (1); Slightly (2); Moderately (3); Very (4); Perfectly (5)

Table 3 - Questionnaire used for the participants of Group B of the soundwalk (Method B of the ISO/TS 12913-2:2018)

Category	Question	Scale/Response Type
Overall quality	How loud is here?	Not at all (1); Slightly (2); Moderately (3); Very (4); Extremely (5)
	How unpleasant is here?	Not at all (1); Slightly (2); Moderately (3); Very (4); Extremely (5)
	How appropriate is the sound to the surrounding?	Not at all (1); Slightly (2); Moderately (3); Very (4); Extremely (5)
	How often would you like to visit this place again?	Never (1); Rarely (2); Sometimes (3); Often (4); Very often (5)
Sound sources	Please list sound sources you noticed in descending order starting with the most noticeable sound source	[open answer, limited to 8 items]
Comments	What is going through your mind?	[open answer]

2.3. Binaural recordings

During the soundwalk, a non-participant operator carried out a head-mounted binaural recorder, as shown in Figure 4. The whole session (i.e., soundwalk + binaural recordings) took place in November 2018, between 02:00 and 04:00 pm of a week day. The weather conditions were sunny and dry, with no significant wind speed and an average temperature of approximately 16° C.

Figure 4 – Examples of sessions at the last three locations of the soundwalk. The operator carrying the headset is highlighted in red

Section 5.6 of the technical specifications specifies that acoustical measurements aimed at informing soundscape research have to consider the way human beings perceive the acoustic environment. For this purpose, calibrated binaural measurement systems are recommended to record an acoustic environment (International Organization for Standardization, 2018).

In this study, binaural acoustical measurements were performed in accordance with Annex D, using a binaural headset BHS II (Head Acoustics) connected to a 4823 MHS III (Head Acoustics) recorder and a laptop using the NoiseBook (Head Acoustics) interface. Table 4 reports the characteristics of the binaural headset used for data acquisition.

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Table 4 - Binaural headset technical data; the device made use of the NoiseBook software as interface

Recording	
Equivalent noise level	Typ. 27 dB(A)
Frequency response	20 Hz to 20 kHz
Microphone supply	2 mA to 10 mA
Maximum sound pressure level	130 dB_{SPL} (THD ≤ 1%)
Playback	
Nominal impedance	90 Ω
Transducer type	Dynamic, open
Ear coupling	Supra-aural
Distortion at 1 kHz	< 1% at 110 dB_{SPL} (300 Hz to 3000 Hz)
Audio transmission range	28 Hz to 17100 Hz

The measurement time was a two-minute interval, which was recorded simultaneously while the participants were listening to the acoustic environment, at each of the eight locations of the soundwalk. During the measurement, the operator (height: 1.70 m) was located at the most typical listener positions, keeping the head steady to perform the recordings in a stationary condition, to avoid any movement that could cause additional noise and introduce a bias in the spatial information of the sound sources. The operator's head was oriented towards the majority of the participants. Also, to minimize the influence of reflections, a minimum distance of 1 m from reflecting surfaces was kept.

2.4. Comparison procedure between Method A and Method B

The information about sound sources prominence in the questionnaire of Method B is not collected using a Likert scale as in the previous method. Participants are instead requested to "rank" up to a maximum of eight different sound sources in an open answer (i.e., no pre-structured sound sources types as per Method A) according to the level of prominence of those, starting from the most salient (first rank) to the least salient (eighth rank maximum). For this reason, in order to make this data comparable to some extent with the scores of the sound sources in Method A, it was necessary to make some recoding. Firstly, the four types of sound sources of Method A were considered (i.e., Traffic noise; Other noise; Sounds from human beings; Natural sounds). Secondly, the free-text answers about sources given by the participants were semantically analysed and classified according to the four categories of Method A (e.g., "voices" would be classified as "Sounds from human beings", "wind" would be classified as "Natural sounds", "construction works" would be classified as "Other noise", etc.). Finally, a new three-level ordinal variable was defined for sound sources dominance. The highest score (3) would correspond to "dominates the acoustic environment" and would be assigned to the first sound source mentioned in the list; the medium score (2) would correspond to "present to some extent" and would be assigned to sound sources mentioned between the second and the seventh rank; and the lowest score (1) would correspond to "barely or not hearable at all" and would be assigned to a sound source mentioned at the eighth rank or not mentioned at all. For instance, the list of a participant reporting "voices, birds, cars" would be recoded into "Sounds from human beings (score: 3); Natural sounds (score: 2); Traffic noise (score: 2); Other noise (score: 1)". Of course, this recoding has limitations as it makes little difference between sound sources other than the first one, but it was assumed that, when using the ranking approach of Method B, participants would focus mostly on the most salient sound, and it would be difficult for the researchers to infer accurate information about prominence from the subsequent ranks in a recoding process.

The two complete sets of questions of methods A and B are not directly comparable since they are constituted of different items, even if some of them overlap or cover similar perceptual dimensions (e.g., the level of "appropriateness" of the sound environment that is present in both methods; or "annoying" in Method A and "unpleasant in Method B). The aim of this work is testing whether the assessment of a soundscape "as a whole" at each location would be consistent, regardless of the questionnaire used. For this purpose, the mean scores of the items of the two methods were computed and separately submitted to cluster analysis, so that each method would result in a soundscape categorisation or "profiling" of the eight locations of the soundwalk.

3. RESULTS

This section reports on the soundscape measures gathered using both Method A and Method B, as well as the results of the psychoacoustic measurements. Eventually, the procedure for processing the outcomes of the two methods and the statistical analysis on their comparison is described.

3.1. Characterization of the acoustic environment

While the results of the questionnaire refer to the exposure to the real acoustic environment, psychoacoustic measures reported were calculated based on the binaural recordings taken during the survey in the same acoustic environment. Overall, during post-processing the following sounds sources were recognised by the researchers in the recordings: natural sounds (bird song), human sounds (people talking and walking), distant and near traffic noise, ventilation noise. Listening and inspection of the audio files were performed by the researchers after the soundwalk for the purpose of validating the materials and checking that no specific anomalous events that could have biased the participants' assessment were present in the excerpts.

In accordance with Annex B of the technical specifications, the psychoacoustic indicators were calculated, using the Artemis (v. 11 – HEAD acoustics GmbH) software, as reported in Tables 5 and 6. Significant effect of the wind gusts on the recordings in the low frequency spectrum at the location 1 couldn't be avoided due to the BHS II limited wind protection. This should be taken into account while observing all the calculated parameters for that location (i.e., outside university classroom). Furthermore the soundwalk at location 1 coincided with a break of the students between lectures, thus several people were outside the building chatting during the recording interval and this resulted in a higher SPL, compared to other quieter moments.

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Table 5 – The results of the measurements according to Annex A.3 – Minimum reporting requirements for the acoustic environment (International Organization for Standardization, 2018), calculated from the binaural recordings using the ArtemiS software

Location		Level (SPL)/dB	Level (SPL)/dBA	Level (SPL)/dBC	Loudness / soneGF	N_5 / sone	N_{95} / sone
1	L	84.9	72.5	81.7	29.7	46.0	29.0
	R	84.7	72.3	81.6	29.3	44.1	28.9
2	L	73.9	60.2	71.4	14.1	22.7	15.7
	R	73.9	62.2	71.4	15.6	27.3	16.7
3	L	81.3	67.1	79.6	22.5	35.0	23.0
	R	81.0	67.0	79.4	21.9	33.0	22.5
4	L	84.4	73.3	82.0	32.9	45.6	34.9
	R	83.3	71.8	81.0	31.1	42.9	33.9
5	L	77.5	68.4	76.0	22.5	34.0	23.8
	R	77.3	67.6	75.6	21.9	32.7	22.9
6	L	76.8	66.8	75.2	22.5	34.0	23.8
	R	76.3	64.8	74.6	20.7	30.0	22.9
7	L	78.7	66.3	76.3	20.7	30.3	22.9
	R	78.8	66.1	76.4	20.8	29.9	23.4
8	L	76.0	63.1	74.6	15.7	25.7	15.8
	R	76.2	64.1	74.8	17.5	29.3	17.6

No unusual or extreme values were measured at any of the locations 2–8. L_{Aeq} at two locations (2 and 8) measured values in the 60 – 65 dBA range, at four locations (3, 5, 6, and 7) in the 65–70 dBA range and at one location (4) it exceeded 70 dBA. The location 4 was highlighted by the highest loudness exceeded in 5% of the time interval value (45.6 sone) and the highest exceeded loudness (34.9 sone) in 95% of the time interval, as well.

Table 6 – Psychoacoustic parameters calculated from the binaural recordings using the ArtemiS software

Location		Sharpness / acum	Tonality / tu	Roughness / asper	Fluctuation Strength / vacil
1	L	2.68	0.0603	2.72	0.0237
	R	2.68	0.0671	2.78	0.0288
2	L	2.35	0.0301	1.04	0.0118
	R	2.66	0.0301	1.32	0.0216
3	L	2.59	0.0767	1.04	0.0217
	R	2.55	0.0767	2.04	0.0219
4	L	2.83	0.0613	2.92	0.0187
	R	2.84	0.0577	2.85	0.0158
5	L	2.35	0.0558	2.03	0.0209
	R	2.40	0.0505	1.99	0.0151
6	L	2.69	0.0541	1.87	0.0144
	R	2.65	0.0474	1.63	0.0113
7	L	2.30	0.0496	1.63	0.0155
	R	2.29	0.0531	1.68	0.0127
8	L	1.93	0.0408	1.11	0.0126
	R	2.21	0.0414	1.32	0.0140

The psychoacoustic measures didn't indicate unusual nor extreme values (sharpness between 1.93 and 2.69 acum, tonality below 0.1 tu, roughness between 1 and 3 asper, fluctuation strength below 0.03 vacil). The location 4 was also characterised by the highest values of most analysed psychoacoustic parameters, possibly because of the significant contribution of ventilation noise. The distribution of the calculated measures shows a fairly diverse sample of consistent acoustic environments which serves the purpose of this paper.

3.2. Soundscape data

3.2.1. Responses collected through Method A

Starting from the analysis of data collected through Method A, in order to simplify data processing and visualization, the scales of the scores of a number of variables were flipped so that a higher score would always reflect a higher level of agreement with the specific item/attribute (see Table 2). The selected items for this re-coding were all the five-point Likert scales of the Perceived affective quality category and the question "Overall, how would you describe the present surrounding sound environment?" (Soundscape quality) in the Overall quality category. The scores of the items of the first category were left as they were (i.e., higher scores correspond to higher prominence of the sound sources), as well as the question "Overall, to what extent is the present surrounding sound environment appropriate to the present place?" (Appropriateness) in the Overall quality category (i.e., the higher the score, the more appropriate the soundscape).

Figure 5 shows the profiles of "prominence" of the sound sources types at the different locations of the soundwalk. Higher prominence of human sounds is reported at locations 1 and 7, where groups of students were chatting/passing. Natural sounds could also be clearly heard at locations 7 and 8, which are closer to the green areas of the campus site. Traffic noise was reported to be prominent at location 3, which is close to the main car entrance to the campus, but almost inaudible at location 4. Possibly it was spectrally masked by the more prominent noise from the air conditioning and ventilation unit on that spot; this is indeed reflected by the higher score of the item "other noise" at location 4.

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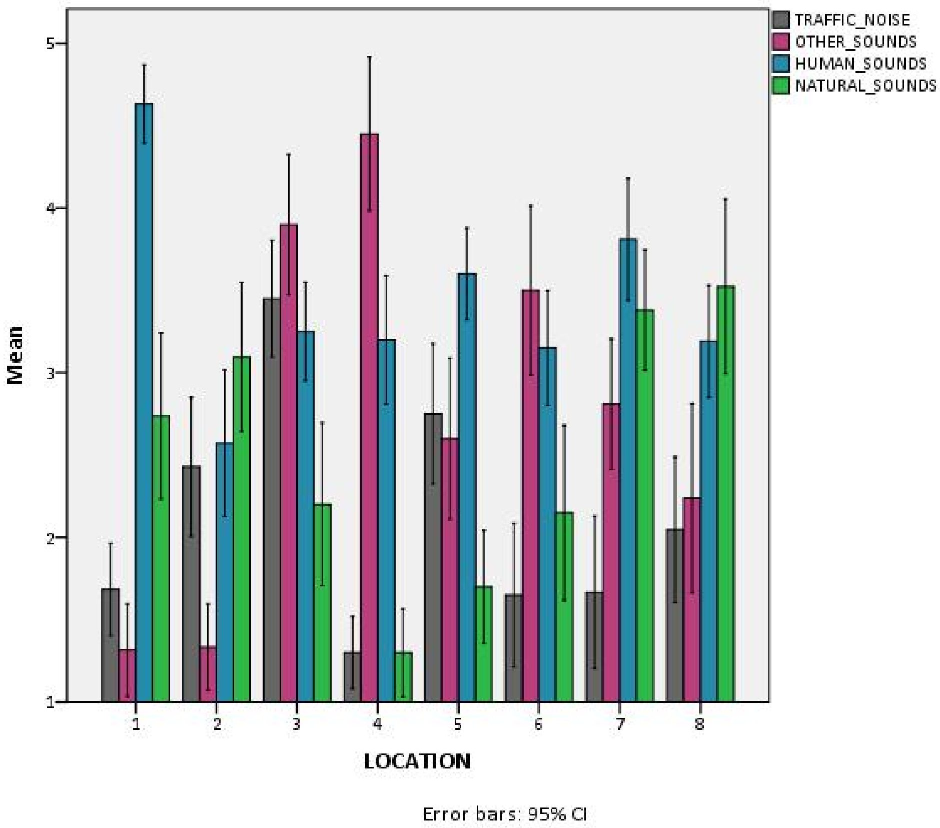

Figure 5 – Mean scores and 95% confidence intervals of the prominence of different sound sources types (first question category in Table 2) at the eight locations of the soundwalk – higher scores imply higher dominance of the sound source type

Figure 6 shows instead the Perceived affective quality "profiles" of the eight locations of the soundwalk. They are plotted on a radar graph to facilitate the interpretation in accordance with the circumplex model for soundscape assessment proposed by Axelsson and colleagues (Axelsson, Nilsson, & Berglund, 2010). It can be observed that locations 2, 7 and 8 mostly cover the calmness and pleasantness regions of the model. These were indeed the "greener" locations where natural sounds where more prominent. Interestingly, location 7 also has a proportionally higher mean score for the "exciting" item, compared to other locations: there were indeed groups of students that led to higher scores of prominence for the human sounds source type. This resulted in the most pleasant scores for this location, where the sample possibly enjoyed a balanced combination of both human and natural sounds.

Finally, Figure 7 shows the mean scores for the items of the Overall quality category of the questionnaire (i.e., Soundscape quality and Appropriateness) at the eight soundwalk locations. Locations 7 and 8 received the highest scores for both items; they had also been scored as the calmest in the Perceived affective quality profiles, suggesting that the sample appreciated the quietness and possibly the greener scenery of the spots. On the opposite hand, Location 4 received the worst scores on both scales, reflecting that the sample was annoyed by the air conditioning and ventilation unit noise, and found it to be intrusive with respect to the context.

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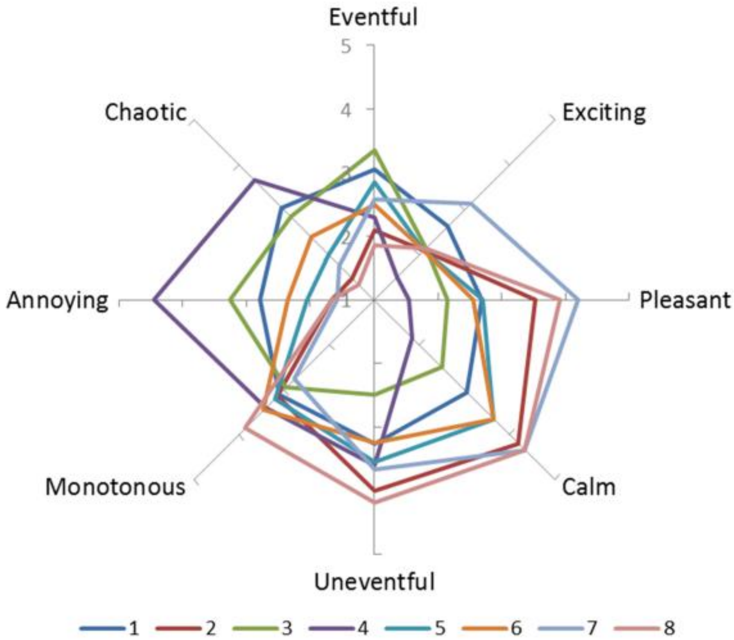

Figure 6 – Mean scores of the Perceived affective quality items (second question category in Table 2) at the eight locations of the soundwalk, plotted in accordance with the circumplex model proposed by (Axelsson, Nilsson, & Berglund, 2010) – higher scores imply higher level of agreement with the specific attribute

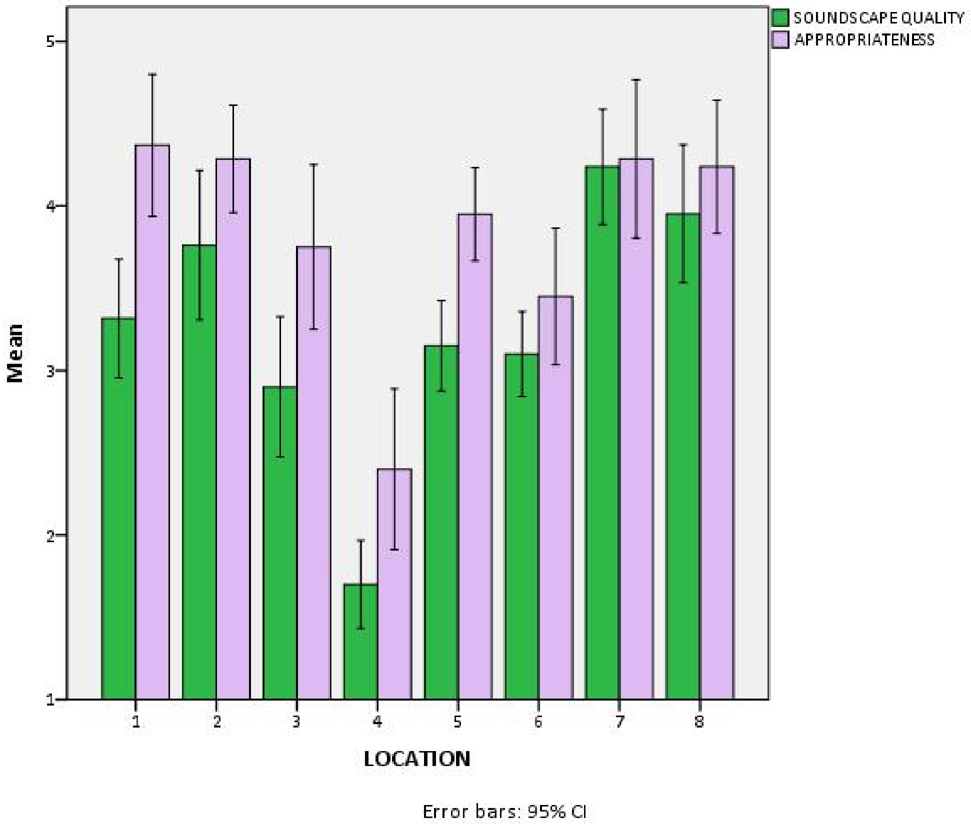

Figure 7 - Mean scores and 95% confidence intervals of the overall soundscape quality and appropriateness (third question category in Table 2) at the eight locations of the soundwalk – higher scores imply higher soundscape quality and appropriateness

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3.2.2. Responses collected through Method B

Taking into account data collected through Method B, the items of the question category Overall soundscape quality of Method B make use of a five-point Likert scale, as per Method A, but refer to different aspects of the acoustic environment perception. The direction of the Likert scales is always positive in this case, meaning that a higher score represents a higher degree of agreement with the attribute in question.

Figure 8 shows the mean scores of the attributes for Overall soundscape quality at the different locations of the soundwalk. A louder and more unpleasant soundscape was reported at location 4, which was indeed also considered the least appropriate and less likely to be visited again in the future by the respondents. The "loud" and "unpleasant" attributes are almost always correlated, except in the case of location 1, where in spite of the relatively loud soundscape (compared to the loud/unpleasant ratio for the other locations), the sample assessed it as one of the least unpleasant and more appropriate. This is possibly due to the fact that the loudness of the soundscape there was mainly determined by a sound source that the sample interpreted to be pleasant and appropriate for the spot: namely the students chatting outside the classrooms building during a break (see also Section 3.1). In general, higher scores of appropriateness corresponded to higher likeliness of visiting the place again.

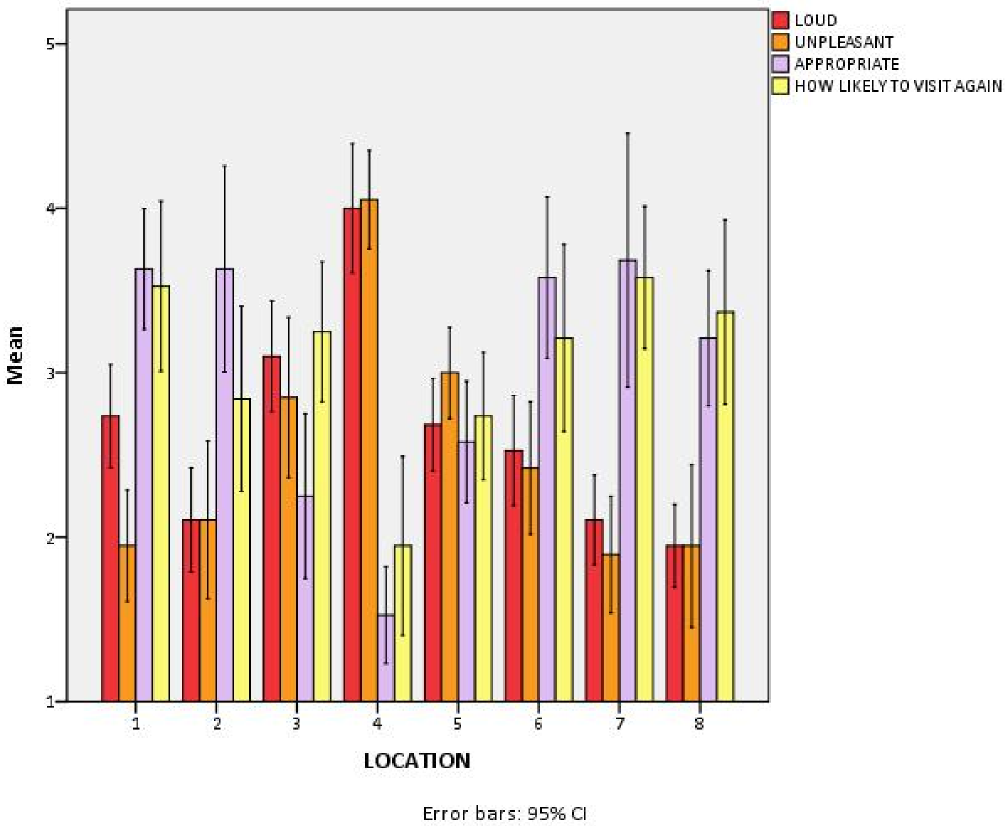

Figure 8 – Mean scores and 95% confidence intervals for the items of Overall soundscape quality (first category question category in Table 3) of the questionnaire in Method B at the eight locations of the soundwalk

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In order to make a comparison between the two methods, the methodological approach previously described in Sub-section 2.4 was applied. After the data set was recoded, it was possible to define similar sound sources prominence profiles for each location, as per Method A. Figure 9 shows that human sounds were considered the most salient sound sources at most locations. Natural sounds are also almost always present to some extent, except at location 4, where they are apparently masked by other noises.

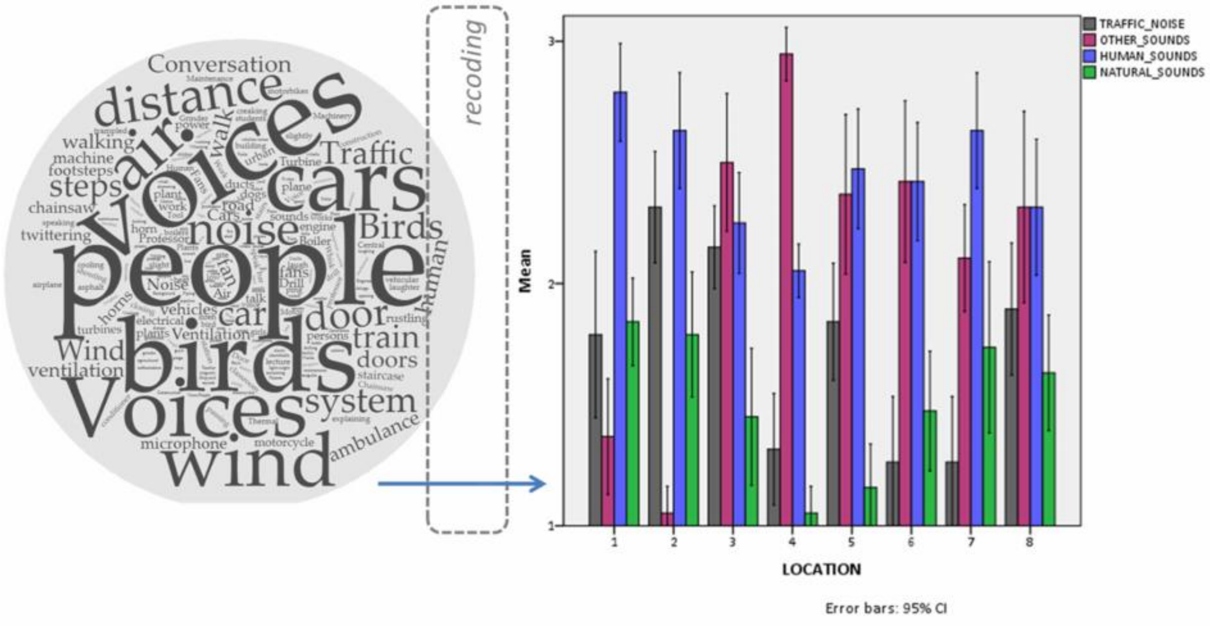

Figure 9 – Schematic representation of the recoding process described in Section 2.4. On the left: word cloud generated from the free-text responses about sound sources dominance in Method B. On the right: mean scores and 95% confidence intervals of the prominence of different sound sources types (second question category in Table 3) at the eight locations of the soundwalk, recoded into a three-point scale: "barely or not hearable at all" (1), "present to some extent" (2), and "dominates the acoustic environment" (3)

3.3. Comparison between the outcomes of Method A and Method B

Being composed of slightly different items, the two methods needed to be referred back to a single data structure and categorisation, so that for each of the eight locations of the soundwalk, two "symmetrical assessments" would be available (one based on Method A and one based on Method B). For this purpose, a clustering approach was adopted for the items of the two questionnaires.

3.3.1. Cluster analysis and soundscape categorisation for Method A

Starting with Method A, a *k*-means cluster analysis was performed on the mean scores of the 14 items of the questionnaire (the three Question categories in Table 2), forcing the algorithm into a two-cluster solution, since a convergence was achieved due to no or small change in cluster centres after only two iterations of the clustering algorithm (SPSS IBM v.22). The mean scores of the questionnaire items were then analysed as a function of cluster membership. It was observed that the scores of the dimensions related to "supportive" soundscapes (e.g., pleasant, calm, appropriate, etc.) were typically higher for cluster 2 than for cluster 1; conversely, the scores of the dimensions related to "detrimental" soundscapes (e.g., annoying, traffic noise, etc.) were typically higher for cluster 1 than for cluster 2.

Consequently, the two clusters were interpreted as: "Negative Soundscape" (1) and "Positive Soundscape" (2). These were then considered as categorical levels of the "Soundscape quality" variable for Method A. In particular, the locations 3 and 4 of the soundwalk were associated to the Negative soundscape category, whilst the remaining ones were associated to the Positive soundscape category.

3.3.2. Cluster analysis and soundscape categorisation for Method B

A similar analysis was carried out for the individual responses gathered through Method B. Although, in this case only the items of the first two categories of Table 3 were considered for the cluster; the qualitative data of the last question category of the method (i.e., Comments) were only visually inspected to confirm the categorisation provided by the clustering algorithm. A *k*-means cluster analysis was then performed on the mean scores of the eight related items of the questionnaire; namely, the four items of Overall quality and the four items related to Sound sources, the latter recoded as explained above in Section 2.4. Also in this case the clustering algorithm was forced into a two-cluster solution, since a convergence was achieved due to no or small change in cluster centres after three iterations (SPSS IBM v.22). The mean scores of the Method B questionnaire items were then analysed as a function of cluster membership. Similarly as per Method A, it was observed that the scores of the dimensions related to "supportive" soundscapes (e.g., appropriate, likeliness to visit the place again, etc.) were typically higher for cluster 2 than for cluster 1; conversely, the scores of the dimensions related to "detrimental" soundscapes (e.g., loud, unpleasant, etc.) were typically higher for cluster 1 than for cluster 2. Consequently, also in this case, the two clusters were interpreted as: "Negative Soundscape" (1) and "Positive Soundscape" (2). These were then considered as categorical levels of the "Soundscape quality" variable for Method B. In particular, for this second clustering process, the locations 3, 4 and 5 of the soundwalk were associated to the Negative soundscape category, while the remaining ones were associated to the Positive soundscape category.

3.3.3. Statistical analysis

The subsequent step was testing whether the newly derived categorical variables would allocate the soundscapes of the eight locations of the soundwalk to the same quality groups (i.e., negative soundscapes or positive soundscapes). For this purpose, a test of association was required. Considering that the data set was too small to meet the sample size assumption of a conventional Chi-square statistics, a maximum likelihood ratio Chi-square test was used instead (McHugh, 2013). There was a statistically significant association between the soundscape quality levels determined using Method A and B, $\chi^2(1) = 5.178$, $p = .023$ and their association was strong, $\varphi = 0.745$, $p = .035$. This is reflected in Figure 10, where it can be observed that the clustering provided through the two methods assigns the eight soundwalk locations substantially to the same categories (negative and positive soundscapes), except for one location, which will be discussed later. Thus, it can be assumed that the two methods return overall similar results.

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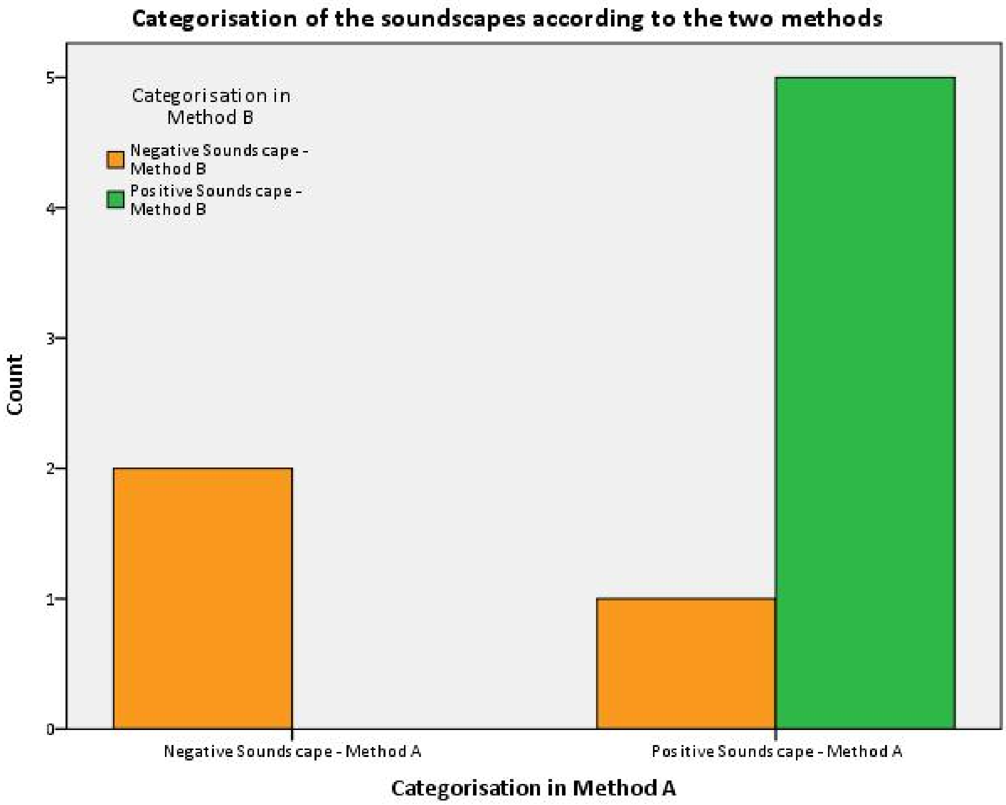

Figure 10 - Association between the categorisation of the soundscape quality of the eight locations of the soundwalk provided through Method A and B; all positive soundscapes (green bar) are identified as such by either method, while one of the negative soundscapes according to Method B (orange bars) is categorised as positive through Method A

Furthermore, in order to provide additional insights into possible correspondences between the two soundscape data collection methods, individual items of the questionnaires were selected when they referred to similar perceptual attributes so that pairwise correlations could be investigated on the mean scores. These were: “annoying” (Method A, see Table 2) and “unpleasant” (Method B, see Table 3); and “appropriate” (for both Methods A and B, see Tables 2 and 3). A Pearson’s product-moment correlation was run to assess the relationship between the mean scores of the items “annoying” and “unpleasant”. There was a statistically significant, strong positive correlation between the two items, $r(6) = .821$, $p = .012$, with an explained variance of 67% as shown in Figure 11a. Likewise, a second Pearson’s product-moment correlation was run to assess the relationship between the mean scores of the “appropriateness” items for Methods A and B. Also in this case, there was a statistically significant, strong positive correlation between the two variables, $r(6) = .780$, $p = .022$, with an explained variance of 61% as shown in Figure 11b.

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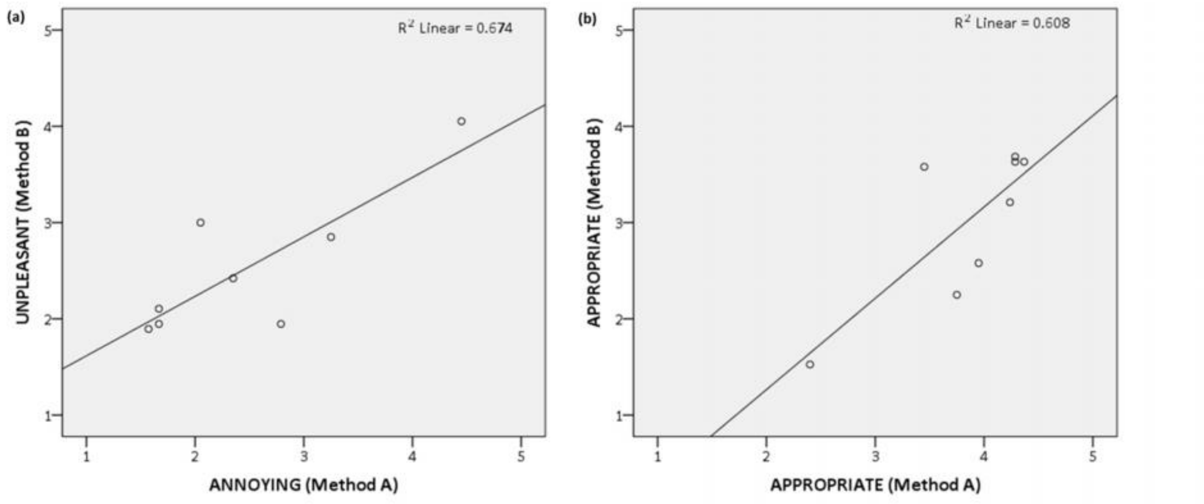

Figure 11 – Scatter plots and linear trends of the mean scores of the items "annoying" and "unpleasant" for Methods A and B, accordingly (a); and the items "appropriate" for both Methods A and B (b)

The questionnaires of Methods A and B cover similar aspects of the perception of the acoustic environments, even if collecting data in a slightly different way. The cluster analysis revealed that soundscape in this case study would be sorted as negative or positive ones with a similar distribution. The only exception in this case study was for location 5 of the soundwalk that was considered being associated to a positive soundscape using Method A, whereas it was associated to a negative soundscape with respect to Method B. When looking at the Overall quality items of the Method B questionnaire, it can indeed be observed that location 5 was rated as the second most unpleasant soundscape of the eight (which was not the case for Method A), in spite of returning similar profiles of sound sources prominence across methods. This raises the question of whether, by asking people to focus on the discomfort aspect (e.g., "How unpleasant is here?"), the sample could be skewed towards negative perceptual dimensions. Furthermore, according to Method B, location 5 received a worse assessment in terms of pleasantness compared to other locations in spite of having a lower SPL; this confirms once again that sound levels alone cannot be considered as a good proxy of experienced soundscape quality.

When looking at the pairwise correlation analysis of the single items of the questionnaires, similar perceptual constructs resulted to be strongly associated across methods. The unexplained amount of variance in the individual scores could be due either to a group effect (i.e., personal factors and differences between the two groups of the soundwalk) or to psychometric aspects, such as the way the question was asked and/or the direction of the assessment attribute. For this reason, further studies, possibly considering repeated-measure within-groups experimental designs would be desirable in the future.

4. DISCUSSION

Standardization in soundscape studies is ongoing and the international scientific community is participating actively to it. This process is already returning some tangible outcomes in the environmental policies panorama and local authorities have started to recommend the soundscape approach for the management of the acoustic environment in accordance with the

EU Environmental Noise Directive (European Parliament and Council, 2002). For instance, the Welsh Government recently released its "Noise and Soundscape Action Plan 2018-2023" for the current five-year period, where soundscape is reported as a necessary strategy to tackle environmental sounds issues (Welsh Government, 2018). For this reason, and in order to make soundscape evaluations a wide-spread practice in environmental studies and impact assessments, it is crucial that researchers and practitioners can rely on robust tools to gather individual soundscape data; this has already been identified as an issue to address in the past (Payne, Davies, & Adams, 2009; Brown, Kang, & Gjestland, 2011; Kang, et al., 2016). The contributions of international networks like the COST TUD Action TD-0804 and the WG54 ISO/TC 43/SC 1 have been particularly important in that direction. Part 1 and Part 2 of the ISO 12913 define a clear structure where more work can be developed. In terms of methods, for example, it has been shown that the Technical specifications suggest questionnaires and interviews. Nevertheless, soundscape might encompass a broader range of methodological approaches to gather perceptual data from people, like laboratory studies (Aletta, Kang, & Axelsson, 2016), non-participant and behavioural observations studies (Lavia, et al., 2018), or crowd-sourced soundscape data (Picaut, et al., 2019). Thus, future revisions of the Technical specifications could also take into account methods other than the survey-based ones, to expand the scope of this discipline.

Another aspect that the ISO working group has provided limited guidance about, so far, is the translation of the soundscape questionnaire protocols in languages other than English. In this study, the Italian translation of the original protocol referred to terms previously used in national studies and possible issues related to the meaning were addressed by training the participants and studying the English and Italian version in parallel, together with the authors, so that misinterpretation of the meaning could be kept to a minimum. While the items of Method B seem to be relatively easy to convert from language to language, the perceptual attributes in Method A (e.g., calm, vibrant, etc.) look more problematic. Indeed, researchers are already experiencing difficulties in translating accurately the meaning of the perceptual dimensions with single words. In an English-Korean comparison study (Jeon, et al., 2018) the attribute "chaotic" was found impossible to render with a single word in Korean and it was eventually replaced with "noisy". Similar problems arise in other Asian and/or character-based languages: a pilot study showed that the soundscape attributes of the circumplex model could not be fully transferred in Japanese without modifications (Nagahata, 2019); likewise, three or four words were often required for an accurate translation of some attributes in Chinese (Mandarin) (Aletta & Kang, 2018). More efforts are therefore needed in overcoming such linguistic barriers to harmonise the tools and achieve the largest possible regional coverage.

Yet, in the context of a soundwalk-based study like the present one, the main point was checking whether there would be any difference in selecting Method A rather than Method B (or vice versa), in terms of general soundscape classification. The ISO 12913-2:2018 does not indicate a clear direction, so one would assume that they return similar (or at least compatible) results. Overall, the findings of this study suggest that this is the case. However, even in a simplified classification procedure where the outcomes of both methods were forced into a dichotomous assessment category of “positive/negative” soundscapes, some differences did emerge. This suggests that the choice of a protocol over another could actually have an effect on the soundscape data that is being gathered. Since the Technical specifications have been released only recently, it is difficult to foresee what the consequences could be on the soundscape community. At this stage, a first option could be performing further studies of comparison between the two methods to investigate whether the differences observed are systematic or not. On the long term, a more viable option could be eventually proposing a revision of the Technical specifications where both methods are combined and used in a complementary way, or more indication could be provided about when to use each method depending on contexts and users.

5. CONCLUSIONS

In the context of soundscape studies, the aim of this paper was testing whether the two methods proposed by the ISO 12913-2:2018 to collect individual responses to the acoustic environment during a soundwalk would return substantially similar results in terms of overall soundscape appreciation. The main conclusions of this study are:

- Overall, for this case study, the two methods of the technical specifications resulted in similar soundscape assessment outcomes with a statistically significant level of association (p = .023), showing that the two methods would discriminate similarly between “positive” and “negative” soundscapes; nevertheless, the association was not total (7 out of 8 cases), suggesting that an integration of the methods would likely be suitable.
- When comparing single items covering similar perceptual constructs across methods (i.e., annoyance and appropriateness), strong statistically significant associations between items were observed ($p < .05$).

Having considered the aspects above, the authors’ recommendation is to use both methods complementarily. This could be done either by splitting participants into multiple groups like in the present study, so that data sources from different methods could be triangulated; or by submitting to participants a new integrated version of the two methods so that a broader spectrum of responses can be gathered. The latter would require further discussion among stakeholders. Taking into account the (even small) differences between the two methods proposed as alternatives in the technical specifications is essential; not doing so might jeopardize the overall goal of the soundscape standardization process, which is providing researchers and practitioners with reliable tools to gather soundscape data that are comparable across contexts and studies, so that further meta-analysis can be potentially conducted and can return empirical evidences of the benefits of implementing the soundscape approach for the management and design of the acoustic environments. Further studies designed in accordance with the standard are indeed desirable to make the soundscape discipline progress and evolve.

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ANNEX I

Table A1 - Questionnaire used for the participants of Group A of the soundwalk (Method A of the ISO/TS 12913-2:2018) – original version in Italian

Category	**Question**	**Item(s)**	**Scale/Response Type**
Sorgenti sonore	In che misura al momento riesci a sentire ciascuna delle seguenti categorie di sorgenti sonore?	• Rumore da traffico veicolare (es., auto, bus, treni, aerei, etc.) • Altri suoni (es., sirene, costruzione, impianti, carico/scarico merci, etc.) • Suoni antropici (es., conversazioni, risate, bambini che giocano, passi, etc.) • Suoni naturali (es., cinguettio, pioggia, vento, fogliame, etc.)	Assolutamente no (1); Un po' (2); Moderatamente (3); Molto (4); Domina completamente (5)
Percezione della qualità affettiva	Per ciascuno dei seguenti 8 attributi, in che misura ritieni che il presente ambiente sonoro sia…	• Piacevole, confortevole • Caotico, confuso • Vivace, stimolante • Stabile, stazionario • Calmo, tranquillo • Spiacevole, irritante • Dinamico, vario • Monotono, noioso	Fortemente d'accordo (1); D'accordo (2); Né d'accordo, né in disaccordo (3); In disaccordo (4); Fortemente in disaccordo (5)
Qualità complessiva	Complessivamente, come descriveresti l'attuale ambiente sonoro in questo luogo?	–	Molto buono (1); Buono (2); Né buono, né cattivo (3); Scarso (4); Molto scarso (5)
	Complessivamente, in che misura ritieni che l'attuale ambiente sonoro sia appropriato per questo luogo?	–	Assolutamente no (1); Leggermente (2); Moderatamente (3); Molto (4); Perfettamente (5)

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Table A2 - Questionnaire used for the participants of Group B of the soundwalk (Method B of the ISO/TS 12913-2:2018) – original version in Italian

Category	Question	Scale/Response Type
Qualità complessiva	Quanto é rumoroso questo luogo?	Assolutamente no (1); Leggermente (2); Moderatamente (3); Molto (4); Estremamente (5)
	Quanto é spiacevole questo luogo?	Assolutamente no (1); Leggermente (2); Moderatamente (3); Molto (4); Estremamente (5)
	Quanto é appropriato il suono al contesto?	Assolutamente no (1); Leggermente (2); Moderatamente (3); Molto (4); Estremamente (5)
	Quanto spesso pensi che visiteresti ancora questo luogo?	Mai (1); Raramente (2); A volte (3); Spesso (4); Molto spesso (5)
Sorgenti sonore	Elenca le sorgenti sonore (fino a un massimo di 8) che hai notato in questo luogo, dalla piú saliente alla meno saliente	[open answer, limited to 8 items]
Commenti	A cosa stai pensando? Descrivi i tuoi pensieri e sentimenti dopo aver ascoltato l'ambiente sonoro	[open answer]

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