Current Pollution Reports
https://doi.org/10.1007/s40726-023-00283-6

Adoption of ISO/TS 12913-2:2018 Protocols for Data Collection From Individuals in Soundscape Studies: an Overview of the Literature

Francesco Aletta[1] · **Simone Torresin**[1,2]

Accepted: 11 October 2023

Abstract

Purpose of Review The article reviews the literature on soundscape studies to analyse (i) which of the methods included in the Technical Specification (TS) 12913-2:2018 by the International Organization for Standardization (ISO) for collecting soundscape data from individuals are predominantly used in scientific research and (ii) what is the level of compliance with ISO recommendations of the methods employed in scientific research.

Recent Findings The ISO/TS 12913-2:2018 provide three possible protocols for individuals' soundscape data collection (Methods A, B, and C). Despite standardization efforts, a reference method has yet to be identified to improve comparability amongst studies and the formation of scientific evidence.

Summary The analysis of 50 peer-reviewed papers published from 2018 (year of release of ISO/TS 12913-2) showed that Method A is the prevalent one, adopted by 94.4% of the identified studies. Full compliance with ISO technical specification recommendations is in any case quite limited, and almost no study is strictly adhering to them. Attributes are not always suitable to cover all the acoustic contexts (e.g. indoor environments). This is an indicator that the field is still developing, but it also signals that technical specification recommendations leave room for ambiguity or are not always implementable. This study is ultimately intended to offer recommendations on future development of the protocols in the standardization process.

Keywords Soundscape · ISO 12913 · Standardization · Data collection · Sound environments

Introduction

The concept of soundscape has become increasingly important in urban studies and related disciplines over the past few decades. The academic community's interest in urban soundscapes can be traced back to the late 1960s, when Michael Southworth wrote a Master of City Planning thesis at MIT on "The Sonic Environment of Cities" [1], and it is generally acknowledged that this was the first appearance of the term in a scholarly context [2]. Five decades later, Southworth himself explained that he aimed to move beyond the traditional focus on visual perception of cities, and to investigate the sensory experience of urban environments that had been overlooked until that time. Despite acknowledging the importance of the visual sense, Southworth acknowledged the significant impact that other senses have on shaping our understanding of places. Due to a keen interest in environmental psychology and how individuals interpret, perceive, and value their surroundings, Southworth collaborated with Kevin Lynch to develop their thesis. They explored concepts such as the tactile and olfactory city, but ultimately found the study of urban sounds to be the most captivating and promising area for research [3]. The concept of soundscape was indeed then further popularised in the following years by other authors such as Schafer [4] and Westerkamp [5], leading to a first proposal in the late 1970s for a definition of "an environment of sound (sonic environment) with emphasis on the way it is perceived and understood by the individual, or by a society" [6]. The study of soundscapes has gained significance because it offers a unique perspective on the social and cultural aspects of urban environments. By focusing on the sounds that make up a particular place, researchers can gain insights into how people interact with and perceive their surroundings, as well as how those surroundings

✉ Francesco Aletta
f.aletta@ucl.ac.uk

[1] The Bartlett, Institute for Environmental Design and Engineering, University College London, Central House, 14 Upper Woburn Place, London WC1H0NN, UK

[2] Department of Civil, Environmental and Mechanical Engineering, University of Trento, Via Mesiano 77, Trento 38123, Italy

Published online: 28 October 2023

impact their well-being and quality of life [7, 8]. Soundscape research has also contributed to the development of new approaches to urban planning and design, such as the use of soundscaping techniques to create more pleasant and liveable environments [9••, 10–12].

The soundscape research community engaged in a standardization process for this emerging field, resulting in the establishment of a Working Group of the International Organization for Standardization (ISO), the Working Group 54 within the ISO/TC 43/SC 1 – Noise, which was tasked to harmonise definitions and methods for data collection and analysis. The ISO released Part 1 of the ISO 12913 standard in 2014, formally defining soundscape as a perceptual construct (i.e. soundscape is the "acoustic environment as experienced, perceived, or understood by a person or people, in context") [13]. The community has debated various approaches for collecting soundscape data, with recurring methods including soundwalks, interviews, listening tests, and focus groups.

Because of the diversity of opinions and expertise involved, Part 2 of the ISO 12913 standard was initially not approved due to a lack of consensus but was eventually accepted in the form of Technical Specifications (TS) [14••]. The ISO/TS 12913-2:2018 provide three possible protocols for individuals' soundscape data collection: two alternative questionnaires for use during a soundwalk (Method A and Method B) and a general protocol for conducting narrative interviews off-site (Method C). Method C is intended as an exploratory tool for residents familiar with the soundscapes being investigated, whilst Methods A and B deal with on-site assessments of perceptual constructs and elements of the acoustic environment. Each method will result in a different approach for data analysis [15]. The technical specifications in Part 2 cover data collection methods and reporting requirements and are implemented via normative and informative annexes. Apart from data sourced from individuals, the technical specifications also include the requirement for binaural recordings as an objective characterization of the acoustic environment, via its normative Annex D, but these are usually less contested and debated. Engel et al. [16••] observed that whilst the ISO/TS 12913-2 standard provide useful guidelines for data collection and reporting in soundscape studies, including the use of triangulation, some researchers use alternative methods such as focus groups and listening tests in laboratory settings.

The ISO/TS 12913-2:2018 present different methods for data collection (some "informative" and some "normative"), but do not really specify how and in which applications these should be prioritised. Aletta et al. [9••] have observed that selecting a protocol over another would likely affect the reported soundscape assessment of a place, and the impact of this ambiguity on research and practice is difficult to quantify [17, 18].

Axelsson, Guastavino, and Payne curated in 2019 a journal special issue on "Soundscape assessment" [19]. They highlighted that a broad range of methods is used in soundscape research, reflecting the interaction between theory and practice. They acknowledged the necessity of such interaction: whilst soundscape theories can guide interventions, the complexity of real-world applications enriches in turn theories and models. That particular collection of scientific publications gathered field and laboratory studies, as well as qualitative and quantitative methods, suggesting that no single method could easily capture all facets of a soundscape. Yet, this diversity of assessment methods makes integration and comparability across results difficult. Standardization efforts should therefore focus on identifying a reference method for enhanced comparability amongst studies. Whilst this was indeed the long-term ambition of the ISO 12913 series, international efforts have not been entirely successful so far. The underlying research questions that this literature review aims to answer are the following:

- Amongst the options offered within the ISO/TS 12913-2:2018 document for collecting soundscape data from individuals, is there a prevailing method/protocol more commonly used in scientific research?
- What level of compliance with the ISO recommendations is there in the utilised methods in scientific research?

ISO standards are developed to create consensus-based documents that reflect the latest industry practices, research, and technological advancements. To ensure that ISO standards remain relevant and up to date, they are reviewed regularly through a process called Systematic Review. During this process, national standard bodies review a given standard (or technical specifications) and its use in their country to decide whether it needs to be updated, confirmed, or withdrawn. This review is ultimately assessing to what extent the protocols recommended in Part 2 of the ISO 12913 series have been adopted in scientific literature, to offer recommendations on future developments of the standardization process.

Methods

Considering the probing nature of the study, no pre-defined protocol was registered for this review. The framework for processing the review items and extracting data from them was agreed upon between the two authors at the beginning of the work. Whilst not perfectly compliant with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for systematic reviews [20], every effort was made to carry out and report the process in the most rigorous way.

Overview of the ISO/TS 12913-2:2018 Document

The structure and the scope of the ISO 12913 series have been abundantly discussed in literature [9••, 21], especially the Technical Specifications of Part 2 and Part 3, published in 2018 and 2019, accordingly. In essence, ISO/TS 12913-2:2018 proposes three possible protocols (Methods A, B, and C) for soundscape data collection with people. The technical specifications cover these instruments and reporting requirements, and are operationalised via a set of normative and informative annexes (Annex C and Annex D, in particular). Method A and Method B propose two alternative questionnaires to be used during a soundwalk, whilst Method C proposes a general protocol for conducting narrative interviews. Hence, the Methods A and B normally deal with soundscape assessments being made on site (or in laboratory studies), whilst Method C is mainly used for off-site investigations. Specific studies on the comparison and compatibility of methods withing the technical specifications are limited at the moment.

Search Strategy and Eligibility Criteria

Scientific publications were identified by searching the SCOPUS database. A combination of the following keywords was used for titles, abstracts, and keywords of the articles: "soundscape" and at "12913" in the references. The search was applied between 1 January 2018 and present. The string search in SCOPUS effectively was "(TITLE-ABS-KEY(soundscape) AND REF(12913))", with outputs limited to 2018–2023 year range.

Inclusion criteria for eligible articles were (1) methodology for data collection must rely on ISO/TS 12913-2:2018; (2) must include primary data collection with people; and (3) must be peer-reviewed literature published in English in international journals in the last 5 years. For the first criterion, regardless of whether the ISO/TS 12913-2 recommendations are fully applied or not, it is important to check that authors explicitly referred to the technical specifications and it is clear from the methodology section that (parts of) the ISO protocols have been actually implemented without substantial deviations (e.g. completely changing the semantic scales or mentioning the ISO but then using essentially different protocols). For the second criterion, the goal is excluding articles that may refer to the soundscape approach or ISO 12913 framework but do not actually source data from people (e.g. sound measurements only, commentary papers, systematic reviews, and meta-analyses). The third and last criterion is applied in response to a requirement of the Current Pollution Reports journal, which aims to "emphasise recently published papers of major importance"; in this case the review is timely as the ISO technical specifications were only published in 2018, so this work is well-positioned to effectively cover most of the relevant literature, as timelines align.

The assessment about the eligibility of the retrieved items was independently performed in a non-blinded standardised manner by the authors. A small number of disagreements between the two authors about inclusion or exclusion of some items were resolved by discussion until consensus was reached. The last database search was performed on 12 April 2023. Using up to three databases is an established method in systematic reviews [20]; nevertheless, Scopus alone was selected in this case, as it has been shown to have broader coverage overall [22] and be more effective at including most of relevant soundscape-related literature in particular, as opposed to other services, such as Web of Science or PubMed [23, 24].

Data Extraction

For each included article, information was extracted by the authors on (1) authors and year of publication; (2) the study design (e.g. whether it was an in situ investigation, a laboratory experiment); (3) the corresponding context used for data collection (e.g. a public outdoor space, a private indoor space); (4) sample size (i.e. number of participants of the study); (5) which method was used for soundscape data collection from individuals (i.e. Method A, Method B, Method C, or combinations of these); (6) whether binaural recordings were included; (7) whether other kinds of person-related and/or perceptual (in non-auditory dimensions) variables were collected in the context of the study (e.g. noise sensitivity, physiological data, lightscape perception) – for this category, common demographics variables, like age, sex, or alike, are not explicitly reported as they are considered to be basic information to be reported in any study; and (8) whether other kinds of objective environmental variables were measured (e.g. illuminance, temperature). For the soundscape data collection from individuals and the binaural recordings, which are the main items regulated via annexes in the ISO technical specifications, the authors aimed to qualitatively assess the compliance of the individual studies, using a four-level classification: not recorded, limited compliance/alternative method (*), partial compliance (**), and stricter compliance (***). This will be shown later in Table 1 in the "Results" section. Due to the often-irreconcilable discrepancies in the methods utilised in the studies selected, it was not feasible to perform a quality assessment and quantitative meta-analysis using the quality-effect model. As a result, a qualitative data synthesis method was employed to address the research questions of this review.

Results

The search through the database and the additional manual search returned 254 results. The abstracts of the retrieved records were screened by the two authors and 80 items were excluded because they were not published in peer-reviewed international journals (e.g. conference proceedings). The full texts of the remaining 174 papers were accessed and 124 of them were excluded because they failed to meet the eligibility criteria (i.e. did not even partially use ISO 12913 for data collection, were review papers or discussion/commentary papers without primary data collection, the full manuscript was not written in English even if title/abstract were), as detailed in Fig. 1, which summarises the selection process of the review items. The remaining 50 papers were included in the full review.

Table 1 shows the data extracted from the 50 studies eventually included in the review, as per the process reported in Fig. 1. After the authors and year of publication, the first bit of information extracted from the included studies is the data collection approach: Annex A of the ISO/TS 12913-2:2018 states that "soundscape studies are primarily conducted as field studies. However, sometimes laboratory studies are also carried out. An example of a field study is a case study of a residential area where the acoustic environment is redeveloped. In such a case it is common to select residents as participants in order to learn how they perceive the acoustic environment and how they would like it to sound (indoors as well as outdoors). Other examples of field studies are evaluations of parks or green areas. In these cases, it is common to select visitors in order to learn how they perceive the park and its acoustic environment. It is also possible to select a panel of participants who are brought to the field study site to evaluate its acoustic environment." Hence, for data extraction, it was determined whether the studies were dealing with laboratory or online listening experiments, or with in situ methods, such as soundwalks and soundscape surveys with visitors of a place (i.e. members of the public). The context of the locations and their corresponding acoustic environments being investigated was also determined; soundscape studies have traditionally been conducted in outdoor settings, but recently emerging research trends show a growing interest in the application of ISO-inspired soundscape methodologies to indoor contexts too [25, 26]. Furthermore, the sample size of the included studies is reported,the ISO technical specifications only refer to a minimum of 20 participants for a soundwalk in Annex C, but do not offer further guidance for different data collection methods. In Table 1, it is reported whether the studies included relied on Method A, Method B, and Method C (Annex C of the ISO document), and Binaural measurements (Annex D of the ISO document): for these

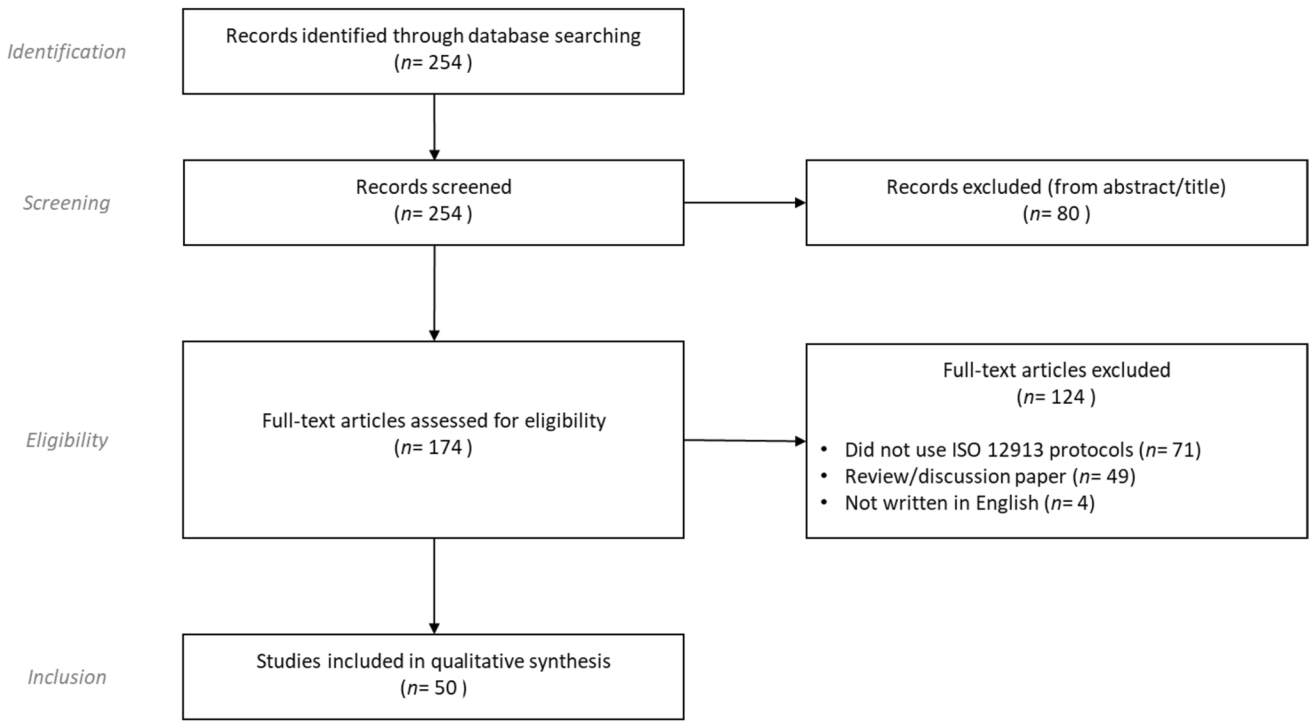

Fig. 1 Flow of information through the different phases of the review process search string: "(TITLE-ABS-KEY(soundscape) AND REF(12913))"

Table 1 List of studies included in the review, items reported in chronological order of publication, from the most recent ones

Authors	Study design	Context	Sample size	Method A	Method B	Method C	Binaural recordings	Other personal or perceptual variables	Other environmental variables
Sun et al. [27]	Soundwalk	Outdoor public space	40	**			**		
	Laboratory listening experiment	Outdoor public space	45	*			**		
Flores-Villa et al. [28]	Soundwalk	Outdoor public space	46	***			**	Lightscape perception	Lighting data
Hong et al. [29]	Outdoor listening experiment	Outdoor public space	48	*			*		
Papadakis et al. [30]	Laboratory listening experiment	Outdoor public space	62	**			**		
Li et al. [31]	Soundscape survey	Outdoor public space	1159	*			*	Education level, occupational status, frequency of visit	
Lam et al. [32]	Soundscape survey	Indoor public space	172	**				Noise sensitivity, Hearing impairment, IEQ	
Nwankwo et al. [33]	Soundscape survey	Outdoor public space	160	*			*	Education level, behavioural data	Weather conditions
Tarlao et al. [34]	Laboratory listening experiment	Outdoor public space	34	**			*		
	Soundscape survey	Outdoor public space	185	**			*	Noise sensitivity, extraversion	
Di Loreto et al. [35]	Online listening experiment	Outdoor public space	228	***			*	Behavioural data	
Hasegawa and Lau [36]	Soundscape survey	Outdoor private space	356	***			*	Education level, noise sensitivity, behavioural data	
Torresin et al. [37]	Online listening experiment	Indoor private space	848	*				Noise sensitivity, behavioural data, contextual data	
Busa et al. [38]	Soundwalk	Outdoor private space	30	**			**		
Heimes et al. [39]	Soundwalk	Outdoor public space	21	**			*		
Sudarsono et al. [40]	Soundwalk	Outdoor public space	5	*	*				
Yang et al. [41]	Soundscape survey	Outdoor public space	123	*			*		Crowd density
Mitchell et al. [42]	Soundscape survey	Outdoor public space	1318	***			**		
	Online listening experiment	Outdoor public space	86	***			**		
Vida et al. [43]	Soundwalk	Outdoor public space	33	**	**		*	Occupational status, education level, well-being	

Table 1 (continued)

Authors	Study design	Context	Sample size	Method A	Method B	Method C	Binaural recordings	Other personal or perceptual variables	Other environmental variables
Jo and Jeon [44]	Laboratory listening experiment	Outdoor public space	50	**			**		
Aletta and Van Renterghem [45]	Soundscape survey	Outdoor public space	109	*			*	Noise sensitivity, COVID-related	
Jo and Jeon [46]	Laboratory listening experiment	Outdoor public space	50	***	***	***	**		
Masullo et al. [47]	Online listening experiment	Outdoor public space	149	*			**	Mood	
Kogan et al. [48]	Soundscape survey	Outdoor public space	129	**			*	Landscape, smellscape	
Jo and Jeon [49••]	Laboratory listening experiment	Outdoor public space	30	**			*	Audio-visual elements, overall environment	
Erfanian et al. [50]	Soundscape survey	Outdoor public space	1134	***			**	Education level, occupational status, ethnicity	
Jeon et al. [51]	Laboratory listening experiment	Outdoor public space	50	***		*	**	Temperament and character dimensions, life satisfaction	Green, sky, and grey ratios
Bilen and Can [52]	Soundscape survey	Outdoor public space	120	*			*		
	Laboratory listening experiment	Outdoor public space	30	*			*		
Van Renterghem et al. [53]	Soundscape survey	Outdoor public space	356	*			*	Overall environment, noise sensitivity, contextual factors, residence, occupational status	
Tarlao et al. [54]	Soundscape survey	Outdoor public space	1429	**	*			Extraversion, noise sensitivity, social interaction	
Mancini et al. [55•]	Soundwalk	Outdoor public space	22	***	***		*		
Ferreira et al. [56]	Soundscape survey	Outdoor public space	180	*	*		*	Overall environment, aesthetic appreciation	
Ali et al. [57]	Laboratory listening experiment	Outdoor public space	37	*	*				
Roa et al. [58]	Soundwalk	Outdoor public space	10			*	*		
Alsina-Pagès et al. [59]	Soundwalk	Outdoor public space	13	*			*		
Puyana-Romero et al. [60]	Laboratory listening experiment	Outdoor public space	50	*			*	Overall environment, aesthetic appreciation, contextual factors	

Table 1 (continued)

Authors	Study design	Context	Sample size	Method A	Method B	Method C	Binaural recordings	Other personal or perceptual variables	Other environmental variables
Hong and Jeon [61]	Soundwalk	Outdoor public space	1142	***			**	Behavioural data	Crowd density
Trudeau et al. [62]	Soundscape survey	Outdoor public space	274	**	*			Contextual factors	
Jo and Jeon [63]	Laboratory listening experiment	Outdoor public space	30	**			**	Behavioural data	
Versümer et al. [64]	Online listening experiment	Indoor private space	1301	*				Education level, residence, income, hearing impairment, extraversion, annoyance, well-being	
Torresin et al. [26]	Laboratory listening experiment	Indoor private space	35	*			**		
Chitra et al. [65•]	Soundscape survey	Outdoor public space	105		***		*		
Lu et al. [66]	Soundwalk	Outdoor public space	62	*					
Meng et al. [67]	Laboratory listening experiment	Outdoor public space	32	*			**	Overall environment, social interaction	
Oberman et al. [68]	Laboratory listening experiment	Outdoor public space	44	***			**		
Acun and Yilmazer [69]	Soundwalk	Indoor public space	15			*		Overall environment	
Aletta et al. [9••]	Soundwalk	Outdoor public space	38	***	***		**		
Sun et al. [70]	Laboratory listening experiment	Outdoor public space	40	*			**	Behavioural data	Green ratio, crowd density
Hong et al. [71]	Laboratory listening experiment	Outdoor public space	30	*			**	Overall environment, contextual information	
Jiang et al. [72]	Online listening experiment	Outdoor public space	100	*			**	Overall environment	
Aletta and Kang [73]	Laboratory listening experiment	Outdoor public space	35	*			**		Crowd density
Aletta et al. [23]	Soundscape survey	Outdoor public space	181	*			*	Overall environment, noise sensitivity, behavioural data, contextual factors	

The table reports about the study design, the context of application, the sample size (number of participants/respondents), the level of compliance with protocols for subjective and objective data collection, and whether personal or other environmental variables were measured in the study. For the levels of compliance, when applicable, these are expressed as ***stricter compliance; **partial compliance; *limited compliance/alternative method used. Some studies included different study designs, and they are reported separately

categories, the authors qualitatively assessed the level of "compliance" with the guidelines (either informative or normative) reported in the ISO/TS 12913-2:2018. Finally, it was determined whether other kinds of personal or environmental variable were considered in the studies and data collected accordingly.

Study Design in Soundscape Studies

In most cases, soundscape studies were based on laboratory listening experiments (n = 17, 31.5%) or soundscape surveys (n = 17, 31.5%), followed by soundwalks (n = 13, 24.1%), online listening experiments (n = 6, 11.1%), and outdoor listening experiments (n = 1, 1.8%). It should be noticed that within the selected papers (n = 50), some studies included more experimental activities which have been reported separately in Table 1 (n = 54). It is interesting to note that, as a general trend, different sample sizes corresponded to different experimental designs. Online listening experiments ($n_{participants}$ = 188 – numbers are medians, unless otherwise stated), soundscape surveys ($n_{participants}$ = 181), and laboratory listening experiments ($n_{participants}$ = 124) generally employed a larger number of participants compared to outdoor listening experiments ($n_{participants}$ = 48) and soundwalks ($n_{participants}$ = 30). This may be related to the fact that the technical specifications request smaller samples for soundscape (approximately 20 people), but also to the more practical aspect that is difficult to coordinate large groups of participants in outdoor contexts and uncontrolled environments for data collection. Almost all studies investigated outdoor soundscapes (n = 49, 90.7%), either in public (n = 47, 87.0%) or private settings (n = 2, 3.7%), and only a few studies referred to the framework given by ISO 12913 to investigate indoor built environments (n = 5, 9.3%), either in public (n = 2, 3.7%) or private settings (n = 3, 5.6%). This is possibly due to the fact that the concept of soundscape itself is only recently being translated into indoor context and there is limited available literature on the topic.

Data Collection for Individual Responses: Methods A, B, and C

The vast majority of the selected studies employed Method A in the data collection (n = 51, 94.4%), followed by those referring to Method B (n = 10, 18.5%) and Method C (n = 4, 7.4%), with a number of papers integrating multiple methods within the same study (n_{A+B}: 8, n_{A+C}: 1, n_{A+B+C}: 1). As for the degree of compliance of the selected studies with the requirements of the technical specification, amongst those that employed Method A (n = 51), 49.0% showed limited compliance (*), 27.5% exhibited partial compliance (**), whilst 23.5% showed more stringent compliance (***). For instance, Hong et al. [29] exhibited limited compliance as they reported on a pleasantness assessment, but on a different scale. Heimes et al. [39] are considered to have partial compliance, as they assessed a set of attributes to describe the affective reaction to the acoustic environment (including those in ISO/TS 12913-2) but on a different scale. The cases of full compliance are very rare: Hong and Jeon [61] both perceived dominance of different sound types (despite being slightly adjusted compared to those included in the standard) and perceived affective quality (using attributes and unidirectional scales of the standard). Amongst the studies that referred to Method B (n = 10), 50.0% showed limited compliance (*), whilst 10.0% (**) and 40.0% (***) followed the indications of the technical specification in a gradually more strict manner. As regards Method C (n = 4), 75.0% exhibited limited compliance to the ISO TS specifications (*), and one study (25.0%) showed stricter compliance (***).

Discussion

Prevalence of ISO Protocols

The literature provides overwhelming evidence supporting the prevalence of Method A, prompting a discussion on ISO's direction regarding its formalization as a normative approach. However, it is essential to recognise that popularity does not necessarily equate to scientific "correctness". Instead, it may simply suggest that Method A is more convenient and suitable for practical applications. Therefore, the ISO Working Group would have to consider various factors before making a decision. One crucial step for ISO is to provide clarity on the contexts in which each method would be most desirable. This clarification would enable users to understand when to employ Method A or consider alternative approaches. By highlighting the specific conditions or scenarios where each method is most effective, ISO can guide practitioners towards the most appropriate choice.

A further challenge lies in standardising the qualitative methods within the Technical Specifications. These methods inherently present difficulties in achieving standardization due to their subjective nature. To accommodate this complexity, the ISO 12913 intentionally allows a degree of flexibility, providing room for deviations and interpretation. However, it is important to note that this flexibility and interpretative space may appear contradictory to the fundamental purpose of standards and technical specifications. Standards aim to establish protocols that can be reliably repeated. Yet, the nature of qualitative methods, which rely on subjective judgment and interpretation, inherently challenges the notion of complete repeatability.

Levels of Compliance with ISO Guidelines

The level of full compliance with the ISO/TS 12913-2:2018 of the reviewed studies is overall rather limited, as it becomes apparent that very few researchers strictly adhere to the technical specifications outlined. This observation serves as an indicator that soundscape theory and methodology is still under development, undergoing continuous refinement and improvement. However, this phenomenon also raises concerns about the ISO's Technical Specifications guidance itself, suggesting that it may leave room for ambiguity and lacks clarity regarding recommended methods and practices.

The lack of widespread strict adherence to ISO standards may signify that researchers and practitioners are still experimenting with different approaches, potentially discovering alternative methods that may be more effective or efficient in certain contexts. This ongoing evolution highlights the dynamic nature of soundscape research and emphasises the need for further debate and development. Yet, the limited compliance may pose an intrinsic risk, as it also raises questions about the actual effectiveness of the technical specifications in providing clear and unambiguous guidance. If the TS adequately addressed the recommended methods and practices, it would be expected that a higher level of conformity would be observed amongst researchers and practitioners. This ambiguity can have several consequences. Firstly, it hinders the comparability and consistency of results obtained by different practitioners or organizations. Without a single and widely accepted approach, it becomes challenging to make meaningful comparisons or draw reliable conclusions from the data collected. Secondly, the lack of clear recommendations may result in inefficiencies or inaccuracies in the application of the methods. Practitioners may resort to trial-and-error or personal preferences, potentially compromising the reliability and validity of their findings. To address these concerns, it becomes crucial for the ISO Working Group to actively engage with practitioners, researchers, and industry experts to gather feedback and promote dialogue. By understanding the challenges faced by those implementing the TS, the ISO Working Group can identify areas of improvement and work towards enhancing the clarity and practicality of the standards.

General Considerations

The high-level findings of this review appear to be that Method A is prevalent as a protocol for data collection from individuals in soundscape scientific literature referencing the ISO 12193 series, and that, nevertheless, there is a low level of compliance with the ISO recommendations in the selected studies. In order to quantify the relative magnitude of the findings above, an attempt was made to calculate their "effect sizes" based on a procedure suggested in qualitative research methods by Sandelowski et al. [74]. According to this protocol, the effect size can be estimated as the ratio between the count of unique studies that contain a given finding (excluding studies stemming from the same original study and presenting the same finding more than once) and the total count of studies (excluding those arising from the same original study and presenting a duplication of the same finding) [74]. In the case of the finding of prevalence of Method A (i.e. studies where *exclusively* Method A is used – see also Table 1), this would result in an effect size of 74% (i.e. 37/50 studies). In the case of the finding of low compliance with the ISO protocols for data collection from individuals (i.e. studies were less than "stricter compliance" was noted in the review – see also Table 1), this would result in an effect size of 76% (i.e. 38/50 studies).

As the body of evidence and scientific literature continues to expand, along with insights gained from professional practice and policy documents, it becomes necessary for the ISO Working Group (WG) to constantly revisit the framework of the ISO 12913 series, and in particular the Technical Specifications for data collection. This re-evaluation (which indeed ISO routinely performs in 5-year cycles as "systematic reviews") is essential to ensure that the standards remain up-to-date and aligned with the latest advancements in the field, or evidence emerging from scientific literature.

In the case of applying the ISO 12913 standards to indoor built environments or non-urban settings, particular attention needs to be given to Method A. It is essential to focus on accurately capturing the dominance of different sound sources within these contexts, even if they differ from the sources indicated in the standard. To facilitate this, it would be highly beneficial to have a comprehensive bank of sound sources from which practitioners can draw. Such a resource would enable them to account for the specific acoustic characteristics and source profiles unique to indoor or non-urban environments, and potentially develop new models of soundscape perception. For instance, when considering the indoor soundscape, it is worth noting that whilst perceptual attributes are available for residential settings [26], there appears to be a gap in literature regarding other building types. It is important for soundscape research to address this discrepancy and develop perceptual attributes that are relevant and applicable across a wider range of building types. By expanding the scope to encompass various indoor environments, ISO can provide a more comprehensive and inclusive framework for assessing and managing the soundscape within different contexts.

Furthermore, even if the focus of the current review was on the ISO protocols for data collection from individuals, as far as binaural measurements were concerned, many inconsistencies and variations in practice were observed. Psychoacoustic parameters from binaural measurements were calculated in different ways, which was something

already observed in soundscape literature [75], and often the assumptions made during these calculations were not clearly specified in the reviewed studies.

Finally, considering additional data extracted from the retrieved articles, 54% of studies included some other personal or perceptual variables (see Table 1). Personal data mostly referred to demographics (education level, occupational status, etc.), noise-related questions (e.g. noise sensitivity, hearing impairment), or behavioural data. This seems to be in line with the recommendations of the technical specifications of Part 2, which in its Annex A (normative) on minimum reporting requirements state that any study should describe how the participants were selected, whether they were residents or visitors for the study site, whether they were lay people, or experts in a field that is relevant to the study, age and gender distribution, and other relevant information [14••]. Other perceptual variables included lightscape, smellscape, and alike, even though these were less prevalent. Moving forward, to enhance the standard, future revisions could incorporate guidelines for researchers to account for these variables, since the technical specifications of Part 3 currently only provide guidance on how to look for associations between the soundscape semantic scales and (psycho)acoustic parameters [15]. Regarding other environmental variables, these were covered only in 13% of the studies, and included crowd density, sky/greenery ratios, weather conditions, and lighting data. Whilst there is little to no reference to such variables in the ISO 12913 series, from a research standpoint, it would be indeed desirable to expand on these lines of enquiry and how other environmental factors interplay with soundscape perception. In this sense, the ISO community is already reacting to such a need, and a new Working Group 68 on "Non-acoustic factors" was established within the ISO Technical Committee 43 Noise (ISO/TC 43/SC 1/WG 68 Non-acoustic factors) to develop new technical specifications on non-acoustic factors influencing the perception, interpretation, and response to environmental sounds [76], which will include several categories, such as personal (perceptual, psychological, mental and physical health), tangible (objective), psychosocial (agreed within affected community), and situational (as experienced in context) factors [77].

Limitations

In the context of this literature review, several limitations were encountered, which should be considered when interpreting the findings. These limitations pertain mostly to the search strategy and consequently to the inclusion criteria.

Some articles may not mention the International Organization for Standardization (ISO) in their methods but be utilising scales or methods that are functionally equivalent to those outlined in the ISO/TS 12913-2:2018 standards (see for instance: [78, 79]. Whilst it is challenging to determine the exact proportion of such articles, it is important to acknowledge their existence. This limitation underscores the need to estimate the prevalence of ISO non-aligned methods and recognise that their use may not be entirely negligible. From an academic community perspective, it is crucial to appreciate the existence of these non-aligned methods, as they contribute to the progression of research. Restricting research solely to ISO-aligned methods could hinder innovation and impede the evolution of ISO standards, creating a paradoxical situation where the ISO itself becomes a limitation to research.

Whilst Method A has been popular in soundscape research, its consistency and suitability across diverse contexts should be more thoroughly tested and refined to ensure its effectiveness in capturing soundscapes [80]. Method B, used in articles which exhibited partial to full compliance with the ISO technical specifications, could benefit from further validation in field studies. Method C had limited usage in the reviewed articles (and these also exhibiting limited compliance), so it may require more extensive testing and validation in field studies, to determine its applicability and reliability in a normative framework.

Additionally, the exclusion of non-English literature presents a limitation in understanding the full landscape of research in different regions of the world. The decision to limit the review to English-language articles was made due to resource constraints and the language abilities of the research team. However, this exclusion prevents a comprehensive understanding of the research landscape across different regions of the world. It is important to acknowledge that valuable research may be published in non-English languages, and by excluding such literature, a potential bias is introduced. To mitigate this limitation, future studies should strive to include non-English literature or collaborate with researchers fluent in relevant languages to obtain a more global perspective. To address the limitation of non-English literature exclusion, the Soundscape Attributes Translation Project (SATP) initiative has been established [81], which will hopefully contribute to a more comprehensive understanding of research advancements and practices from diverse regions, helping to fill the gaps created by language restrictions in soundscape-related systematic literature reviews [82].

Conclusions

The field of soundscape research presents exciting opportunities and challenges that require careful consideration. This literature review has highlighted several key points that could be taken into account for the future development of soundscape-related standards, and overall advancement

of the field. It is crucial to approach existing methods and results with a critical lens: continual evaluation and scrutiny of methodologies for soundscape data collection and findings can contribute to the refinement and improvement of the framework proposed by the ISO 12913 series.

The literature review focused on addressing two main objectives: namely determining whether there is a prevalent method in scientific research amongst the options provided in the ISO/TS 12913-2 for collecting soundscape data from individuals and assessing the level of compliance with the ISO recommendations within the methods utilised in scientific research for collecting soundscape data from individuals. The main findings of the review are that Method A is currently more prevalent and there is overall only partial to low compliance with the ISO technical specifications for collecting soundscape data from individuals.

For soundscape research and practice, it is equally important to seek common ground and objectives for the discipline development. Soundscape research benefits from international and interdisciplinary collaboration, bringing together diverse perspectives and expertise. Through collaborative efforts, researchers can foster a shared understanding, exchange knowledge, and establish consensus on key concepts, methods, and practices. This collective approach accelerates progress and facilitates the establishment of a unified framework for soundscape research. In this context, the International Organization for Standardization (ISO) plays of course a significant role. The periodic review of international standards and technical specifications ensures their relevance and technical accuracy. By incorporating scientific evidence and expert input, the ISO strives to bridge the gap between research and practice. The ISO's overarching goal is to provide communities with science-informed standards that guide and inform soundscape assessment and management. As the field evolves and new insights emerge, it is expected that the findings from this literature review will contribute to future rounds of review for the documents within the ISO 12913 series. The hope is that the research presented here can inform and influence the next iterations of ISO standards, ultimately enhancing the overall quality and effectiveness of soundscape research.

Author Contributions F.A. and S.T. designed the study; F.A. and S.T. carried out the screening for inclusion of the studies; F.A. analyzed the data; F.A. wrote the original draft and prepared Fig. 1 and Table 1; F.A. and S.T. edited and reviewed the manuscript.

Data Availability The raw data are available from the authors upon request.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Southworth M. The sonic environment of cities. Environ Behav. 1969;1(1):3–99.
2. Axelsson Ö. Soundscape revisited. J Urban Des. 2020;25(5):551–5.
3. Southworth M. Listening to the city. J Urban Des. 2020;25(5):556–60.
4. Schafer RM. The soundscape: our sonic environment and the tuning of the world. Simon and Schuster; 1993.
5. Westerkamp H. The disruptive nature of listening: today, yesterday, tomorrow. In: Sound, media, ecology. Cham: Palgrave Macmillan; 2019. p. 45–63.
6. Truax B. Acoustic ecology and the world soundscape project. In: Sound, media, ecology. Cham: Palgrave Macmillan; 2019. p. 21–44.
7. Aletta F, Oberman T, Kang J. Associations between positive health-related effects and soundscapes perceptual constructs: a systematic review. Int J Environ Res Public Health. 2018;15(11):2392.
8. Radicchi A, Cevikayak Yelmi P, Chung A, Jordan P, Stewart S, Tsaligopoulos A, McCunn L, Grant M. Sound and the healthy city. Cities Health. 2021;5(1–2):1–3.
9. •• Aletta F, Guattari C, Evangelisti L, Asdrubali F, Oberman T, Kang J. 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. Appl Acoust. 2019;155:190–203. **This paper looked specifically at whether Methods A and B of the ISO 12913 technical specifications would return similar results in a controlled soundwalk.**
10. Kang J, Aletta F, Gjestland TT, Brown LA, Botteldooren D, Schulte-Fortkamp B, Lercher P, van Kamp I, Genuit K, Fiebig A, Coelho JL. Ten questions on the soundscapes of the built environment. Build Environ. 2016;108:284–94.

11. Kang J, Aletta F, Oberman T, Mitchell A, Erfanian M, Tong H, Torresin S, Xu C, Yang T, Chen X. Supportive soundscapes are crucial for sustainable environments. Sci Total Environ. 2023;855: 158868.
12. Schulte-Fortkamp B, Fiebig A. Soundscape analysis in a residential area: an evaluation of noise and people's mind. Acta Acust Acust. 2006;92(6):875–80.
13. ISO - International Organization for Standardization. ISO 12913–1:2014 Acoustics – soundscape – Part 1: definition and conceptual framework. Geneva: ISO; 2014.
14.•• ISO - International Organization for Standardization. ISO/TS 12913–2:2018 Acoustics – soundscape – Part 2: data collection and reporting requirements. Geneva: ISO; 2018. **This is the main ISO document that reports on the methods described in the current literature review.**
15. ISO - International Organization for Standardization. ISO/TS 12913–3:2019 Acoustics – soundscape – Part 3: data analysis. Geneva: ISO; 2019.
16.•• Engel MS, Fiebig A, Pfaffenbach C, Fels J. A review of socio-acoustic surveys for soundscape studies. Curr Pollut Rep. 2018;4:220–39. **This paper is an important pioneering review of methodological approaches in soundscape data collection (regardless of ISO-compliance).**
17. Heggie C, Smyrnova J, Smith B, Allen M, Klein A. The practicalities of soundscape data collection by systematic approach according to ISO 12913–2. In: INTER-NOISE and NOISE-CON Congress and Conference Proceedings, vol. 259, no. 6. Institute of Noise Control Engineering; 2019. p. 3747–58.
18. Jo HI, Seo R, Jeon JY. Soundscape assessment methods: compatibility of questionnaires and narrative interview based on ISO 12913–2. In: INTER-NOISE and NOISE-CON Congress and Conference Proceedings, vol. 261, no. 3. Institute of Noise Control Engineering; 2020. p. 3509–18.
19. Axelsson Ö, Guastavino C, Payne SR. Soundscape assessment. Front Psychol. 2019;10:2514.
20. Moher D, Liberati A, Tetzlaff J, Altman DG, Prisma Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int J Surg. 2010;8(5):336–41.
21. Mitchell A, Aletta F, Kang J. How to analyse and represent quantitative soundscape data. JASA Express Lett. 2022;2(3): 037201.
22. Singh VK, Singh P, Karmakar M, Leta J, Mayr P. The journal coverage of web of science, scopus and dimensions: a comparative analysis. Scientometrics. 2021;126:5113–42.
23. Aletta F, Van Renterghem T, Botteldooren D. Influence of personal factors on sound perception and overall experience in urban green areas. A case study of a cycling path highly exposed to road traffic noise. Int J Environ Res Public Health. 2018;15(6):1118.
24. Kang J, Aletta F. The impact and outreach of soundscape research. Environments. 2018;5(5):58.
25. Torresin S, Albatici R, Aletta F, Babich F, Kang J. Assessment methods and factors determining positive indoor soundscapes in residential buildings: a systematic review. Sustainability. 2019;11(19):5290.
26. Torresin S, Albatici R, Aletta F, Babich F, Oberman T, Siboni S, Kang J. Indoor soundscape assessment: a principal components model of acoustic perception in residential buildings. Build Environ. 2020;182: 107152.
27. Sun C, Meng Q, Yang D, Wu Y. Soundwalk path affecting soundscape assessment in urban parks. Front Psychol. 2023;13:1096952.
28. Flores-Villa L, Oberman T, Guattari C, Asdrubali F, Frascarolo M, Puglisi GE, ... Aletta F. Exploring relationships between soundscape and lightscape perception: A case study around the Colosseum and Fori Imperiali in Rome. Light Res Technol. 2023;14771535231156617.
29. Hong XC, Cheng S, Liu J, Dang E, Wang JB, Cheng Y. The physiological restorative role of soundscape in different forest structures. Forests. 2022;13(11):1920.
30. Papadakis NM, Aletta F, Kang J, Oberman T, Mitchell A, Stavroulakis GE. Translation and cross-cultural adaptation methodology for soundscape attributes–A study with independent translation groups from English to Greek. Appl Acoust. 2022;200:109031.
31. Li W, Zhai J, Zhu M. Characteristics and perception evaluation of the soundscapes of public spaces on both sides of the elevated road: a case study in Suzhou, China. Sustain Cities Soc. 2022;84: 103996.
32. Lam B, Fan EM, Ooi K, Ong ZT, Hong JY, Gan WS, Ang SY. Assessing the perceived indoor acoustic environment quality across building occupants in a tertiary-care public hospital in Singapore. Build Environ. 2022;222: 109403.
33. Nwankwo M, Meng Q, Yang D, Liu F. Effects of forest on birdsong and human acoustic perception in urban parks: a case study in Nigeria. Forests. 2022;13(7):994.
34. Tarlao C, Steele D, Guastavino C. Assessing the ecological validity of soundscape reproduction in different laboratory settings. PLoS ONE. 2022;17(6): e0270401.
35. Di Loreto S, Serpilli F, Lori V. Soundscape approach in the seaport of Ancona: a case study. Acoustics. 2022;4(2):492–516. MDPI.
36. Hasegawa Y, Lau SK. Comprehensive audio-visual environmental effects on residential soundscapes and satisfaction: partial least square structural equation modeling approach. Landsc Urban Plan. 2022;220: 104351.
37. Torresin S, Albatici R, Aletta F, Babich F, Oberman T, Kang J. Associations between indoor soundscapes, building services and window opening behaviour during the COVID-19 lockdown. Build Serv Eng Res Technol. 2022;43(2):225–40.
38. Busa L, Goretti M, Guattari C, Pulella P. Extra-auditory effects of noise exposure in Italian schools: noise levels in external areas. Noise Mapp. 2022;9(1):227–33.
39. Heimes A, Yang M, Vorländer M. Virtual reality environments for soundscape research. Vib Phys Syst. 2022;33(1).
40. Sudarsono AS, Setiasari W, Sarwono SJ, Nitidara NP. The development of standard perceptual attributes in Indonesian for soundscape evaluation: result from initial study. J Appl Sci Eng. 2021;25(1):215–22.
41. Yang D, Cao X, Meng Q. Effects of a human sound-based index on the soundscapes of urban open spaces. Sci Total Environ. 2022;802: 149869.
42. Mitchell A, Oberman T, Aletta F, Kachlicka M, Lionello M, Erfanian M, Kang J. Investigating urban soundscapes of the COVID-19 lockdown: a predictive soundscape modeling approach. J Acoust Soc Am. 2021;150(6):4474–88.
43. Vida J, Almagro JA, García-Quesada R, Aletta F, Oberman T, Mitchell A, Kang J. Urban soundscape assessment by visually impaired people: first methodological approach in Granada (Spain). Sustainability. 2021;13(24):13867.
44. Jo HI, Jeon JY. Overall environmental assessment in urban parks: modelling audio-visual interaction with a structural equation model based on soundscape and landscape indices. Build Environ. 2021;204: 108166.
45. Aletta F, Van Renterghem T. Associations between personal attitudes towards COVID-19 and public space soundscape assessment: an example from Antwerp, Belgium. Int J Environ Res Public Health. 2021;18(22):11774.
46. Jo HI, Jeon JY. Urban soundscape categorization based on individual recognition, perception, and assessment of sound environments. Landsc Urban Plan. 2021;216: 104241.

47. Masullo M, Maffei L, Iachini T, Rapuano M, Cioffi F, Ruggiero G, Ruotolo F. A questionnaire investigating the emotional salience of sounds. Appl Acoust. 2021;182: 108281.
48. Kogan P, Gale T, Arenas JP, Arias C. Development and application of practical criteria for the recognition of potential Health Restoration Soundscapes (HeReS) in urban greenspaces. Sci Total Environ. 2021;793: 148541.
49.•• Jo HI, Jeon JY. Compatibility of quantitative and qualitative data-collection protocols for urban soundscape evaluation. Sustain Cities Soc. 2021;74:103259. **This is the only study retrieved in literature that systematically looks at comparability of the Methods A, B, and C of the ISO/TS 12913-2:2018.**
50. Erfanian M, Mitchell A, Aletta F, Kang J. Psychological well-being and demographic factors can mediate soundscape pleasantness and eventfulness: a large sample study. J Environ Psychol. 2021;77: 101660.
51. Jeon JY, Jo HI, Lee K. Potential restorative effects of urban soundscapes: personality traits, temperament, and perceptions of VR urban environments. Landsc Urban Plan. 2021;214: 104188.
52. Bilen AO, Can ZY. An applied soundscape approach for acoustic evaluation–compatibility with ISO 12913. Appl Acoust. 2021;180: 108112.
53. Van Renterghem T, Aletta F, Botteldooren D. Changes in the soundscape of the public space close to a highway by a noise control intervention. Sustainability. 2021;13(9):5284.
54. Tarlao C, Steffens J, Guastavino C. Investigating contextual influences on urban soundscape evaluations with structural equation modeling. Build Environ. 2021;188: 107490.
55.• Mancini S, Mascolo A, Graziuso G, Guarnaccia C. Soundwalk, questionnaires and noise measurements in a university campus: a soundscape study. Sustainability. 2021;13(2):841. **This is one of the few studies applying both Methods A and B with good level of compliance as per the ISO/TS 12913-2:2018.**
56. Ferreira LR, Borges EF, de Campos Grigoletti G. Subjective analysis of soundscape in three areas in the Brazilian city in the legal Amazon region. Can Acoust. 2021;49(4).
57. Ali M, Gabr HS, Mahmoud AH, Aboubakr D. Assessing and characterizing the perception of soundscape in the Urban Park: a case study of Zayed Park, Egypt. Eng Sci. 2021;16:393–402.
58. Roa M, Vetterick M, Siebein GW. Chiller plant full-scale acoustic simulation in a quiet neighborhood. Cities Health. 2021;5(1–2):61–70.
59. Alsina-Pagès RM, Ginovart-Panisello GJ, Freixes M, Radicchi A. A soundwalk in the heart of Poblenou superblock in Barcelona: preliminary study of the acoustic events. Noise Mapp. 2021;8(1):207–16.
60. Puyana-Romero V, Maffei L, Brambilla G, Nuñez-Solano D. Sound water masking to match a waterfront soundscape with the users' expectations: the case study of the seafront in Naples, Italy. Sustainability. 2021;13(1):371.
61. Hong JY, Jeon JY. Comparing associations among sound sources, human behaviors, and soundscapes on central business and commercial streets in Seoul, Korea. Build Environ. 2020;186: 107327.
62. Trudeau C, Steele D, Guastavino C. A tale of three misters: the effect of water features on soundscape assessments in a Montreal public space. Front Psychol. 2020;11: 570797.
63. Jo HI, Jeon JY. The influence of human behavioral characteristics on soundscape perception in urban parks: subjective and observational approaches. Landsc Urban Plan. 2020;203: 103890.
64. Versümer S, Steffens J, Blättermann P, Becker-Schweitzer J. Modeling evaluations of low-level sounds in everyday situations using linear machine learning for variable selection. Front Psychol. 2020;23(11): 570761.
65.• Chitra B, Jain M, Chundelli FA. Understanding the soundscape environment of an urban park through landscape elements. Environ Technol Innov. 2020;19:100998. **This paper is a rare example in literature of Method B being accurately applied in isolation (i.e., without integrations from Method A or C) for soundscape data collection.**
66. Lu X, Tang J, Zhu P, Guo F, Cai J, Zhang H. Spatial variations in pedestrian soundscape evaluation of traffic noise. Environ Impact Assess Rev. 2020;83: 106399.
67. Meng Q, Hu X, Kang J, Wu Y. On the effectiveness of facial expression recognition for evaluation of urban sound perception. Sci Total Environ. 2020;710: 135484.
68. Oberman T, Jambrošić K, Horvat M, Bojanić Obad Šćitaroci B. Using virtual soundwalk approach for assessing sound art soundscape interventions in public spaces. Appl Sci. 2020;10(6):2102.
69. Acun V, Yilmazer S. Combining Grounded Theory (GT) and Structural Equation Modelling (SEM) to analyze indoor soundscape in historical spaces. Appl Acoust. 2019;155:515–24.
70. Sun K, De Coensel B, Filipan K, Aletta F, Van Renterghem T, De Pessemier T, Joseph W, Botteldooren D. Classification of soundscapes of urban public open spaces. Landsc Urban Plan. 2019;189:139–55.
71. Hong JY, Lam B, Ong ZT, Ooi K, Gan WS, Kang J, Feng J, Tan ST. Quality assessment of acoustic environment reproduction methods for cinematic virtual reality in soundscape applications. Build Environ. 2019;149:1–4.
72. Jiang L, Masullo M, Maffei L, Meng F, Vorländer M. How do shared-street design and traffic restriction improve urban soundscape and human experience?–An online survey with virtual reality. Build Environ. 2018;143:318–28.
73. Aletta F, Kang J. Towards an urban vibrancy model: a soundscape approach. Int J Environ Res Public Health. 2018;15(8): 1712.
74. Sandelowski M, Barroso J, Voils CI. Using qualitative metasummary to synthesize qualitative and quantitative descriptive findings. Res Nurs Health. 2007;30(1):99–111.
75. Engel MS, Fiebig A, Pfaffenbach C, Fels J. A review of the use of psychoacoustic indicators on soundscape studies. Curr Pollut Rep. 2021;7:359–78.
76. ISO - International Organization for Standardization. ISO/ AWI TS 16755–1 Acoustics – non-acoustic factors – Part 1: definition and conceptual framework. Geneva: ISO; 2023.
77. Fenech B, Lavia L, Rodgers G, Notley H. Development of a new ISO Technical Specification on non-acoustic factors to improve the interpretation of socio-acoustic surveys. Paper presented at the 13th ICBEN Congress on Noise as a Public Health Problem; 2021. p. 14–7.
78. Boucherit S, Maffei L, Masullo M, Berkouk D, Bouzir TA. Assessment of sighted and visually impaired users to the physical and perceptual dimensions of an oasis settlement urban park. Sustainability. 2023;15(8):7014.
79. De Pessemier T, Van Renterghem T, Vanhecke K, All A, Filipan K, Sun K, De Coensel B, De Marez L, Martens L, Botteldooren D, Joseph W. Enhancing the park experience by giving visitors control over the park's soundscape. J Ambient Intell Smart Environ. 2022;14(2):99–118.
80. Aletta F, Oberman T, Mitchell A, Erfanian M, Kang J. Soundscape experience of public spaces in different world regions: a comparison between the European and Chinese contexts via a large-scale on-site survey. J Acoust Soc Am. 2023;154(3):1710–34.
81. Aletta F, Oberman T, Axelsson Ö, Xie H, Zhang Y, Lau SK, Tang SK, Jambrošić K, De Coensel B, Van den Bosch K, Aumond P. Soundscape assessment: towards a validated translation of perceptual attributes in different languages. In: Inter-Noise and Noise-Con Congress and Conference Proceedings, vol. 261, no. 3. Institute of Noise Control Engineering; 2020. p. 3137–46.

82. Yörükoğlu PD, Bayrak ÖT, Çoban NA, Osma UE, Aletta F, Oberman T, Mitchell A, Kang J. Translation of soundscape perceptual attributes from English to Turkish. Appl Acoust. 2023;209: 109391.