Research Article

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A framework to characterize and classify soundscape design practices based on grounded theory

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Abstract: In recent years, various stakeholders and political decision-makers have recognized the significance of high-quality urban sound environments, stressing the need for user-centered trajectories. Despite the rising interest in this field, the soundscape approach has not yet fully permeated urban planning and design, possibly due to a lack of comprehensible guidelines on how to implement and curate successful soundscape designs, attributed to ongoing developments on this subject. In the course of the Catalogue of Soundscape Interventions (CSI) Project, a taxonomy of eight dimensions was developed to serve as an orientation aid for practitioners, describing important aspects of soundscape-related measures that can be used as a brief to facilitate communication between authorities, consultants, and researchers. This study describes the theoretical framework and, in particular, the sequential coding process involved in deriving these dimensions, which is based on grounded theory. It lists observations and limitations of the resulting taxonomy and builds upon these findings to critically review and revisit existing nomenclature and concepts. Finally, a qualitative distinction in the form of a design pyramid according to ascending levels of epistemic rigor is proposed, to differentiate between documented practices, which may serve as a reference point for future harmonization and standardization.

Keywords: soundscape design strategies, soundscape interventions, grounded theory, pyramid, ISO/TS 12913-4

1 Introduction

Environmental noise, particularly traffic noise, is a frequent cause of distress and concern on a global level, due to many health risks associated with it, including cardiovascular diseases, sleep disturbances, cognitive impairment, and reduced quality of life [1–4]. It also poses a substantial financial burden [5] and has threatening implications for biodiversity [6,7].

The Environmental Noise Directive (END) [8] of the European Union provides a key instrument to protect people's health and well-being from the negative effects of noise by targeting the reduction of noise emissions. However, despite its unquestionable merit, it has several shortcomings. First, and in accordance with conventional noise abatement, the END focuses primarily on noise-level reduction, either at the source or through the designation and protection of quiet areas. However, it is well known that an acoustic factors such as sound level account for only about one-third of the variance of noise annoyance caused by road traffic noise [9]. Furthermore, measuring exposure responses to singular, usually traffic-related sound sources does not do the complexity of an acoustic environment justice, given that these environments consist of a multitude of interplaying sounds that have to be considered individually, but also in their entirety [10]. Second, the END does not address social and infrastructural inequalities in exposure to environmental noise. In neglecting to do so, it overlooks that disadvantaged communities have a higher chance of being negatively affected by noise [11–13] and that clustered, high-density cities display higher levels of annoyance complaints [14]. Such factors are important to consider when conceptualizing measures, because they imply that

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certain populations and focal points may need to be prioritized. Third, the END does not account for context-related aspects that can influence and alter the way people interact with their acoustic environments. These aspects encompass functional demands of a space, *e.g.*, motivation, timing and frequency of use, effects of other sensory modalities, but also include expectations, experiences, and attitudes toward sounds. Achieving better acoustic comfort and long-term improvements in quality of life must therefore involve more differentiated strategies [15,16]. Thus, it has to be constituted that the success of conventional approaches remains modest, given that policy objectives on environmental noise have not yet been achieved and that the number of people exposed to harmful levels of noise remains almost unchanged over the last decade [17].

Originally rooted in music and acoustic ecology, the field of soundscape has the potential to fill the gaps of conventional noise control, due to its holistic approach and its focus on how people perceive and experience acoustic environments. In doing so, it marks a paradigm shift in the way sound environments are assessed, because it extends beyond a mere quantification of physical phenomena. By considering environmental sounds to be a "resource," as opposed to "waste," soundscape focuses on sound preferences rather than sound discomforts [18]. It thereby highlights the potential of cohesive, harmonious, and pleasant acoustic environments in promoting health and well-being. Indeed, studies have consistently found links between positively experienced soundscapes and enhanced restoration, stress recovery, and cognitive performance [19–21]. Next to facilitating positive outcomes on health, soundscape can also promote the preservation of cultural heritage and help alleviate economic costs, by increasing property value and reducing offset health costs through the provision of restorative living spaces [22].

Due to its positivistic standpoint and its allowed flexibility, the value of soundscape has been recognized by governmental organizations. It has attracted the attention of various agents of the built environment, who call for consultation and participation of the public in preparation and review of action plans and for a more user-centered approach to the characterization, management, and design of urban acoustic environments [23–28].

Fueled by this development, the number of soundscape studies focusing on urban environments has skyrocketed in the past decade, as confirmed by a recent scientometric study [29]. However, despite the field's growing popularity, it has yet to make a significant breakthrough in the planning and design community. This may be owing to a lack of empirical evidence showcasing the long-term benefits of soundscape, but also to differences in shared vocabulary, conceptualizations, and resources [30]. More importantly, although the ISO/TS 12913 series provides a theoretical and methodological framework to analyze and assess soundscapes, there is little information available on how to actually implement and curate soundscape-related measures in real contexts and which factors to consider during the planning and implementation process. However, this information is particularly important, because the success, effectiveness, and enduring impact of such measures hinge upon it. Moreover, the absence of a practical "roadmap" could explain why soundscape-oriented solutions have not permeated urban planning. Thus, the need to establish and deliver practical guidelines to implement and assess successful soundscape designs arises, as reflected by Part 4 of the ISO/TS 12913 series, currently under development [31].

To facilitate guideline development, the Catalogue of Soundscape Interventions (CSI) project was initiated to document, identify, and evaluate overreaching themes and execution practices of soundscape-related measures in real-world settings [32–34]. Having systematized different aspects of soundscape-related measures in our previous work by developing a taxonomy [35], we aim to extend our findings by answering the following research questions:

(1) How do outputs from the CSI taxonomy align with observations reported in previous compilations of soundscape-related measures?
(2) Which concepts of a "soundscape intervention" can be derived from the CSI?
(3) What types of practices are represented in the CSI, how do they differ from each other, and how can they be systematically classified?

In order to answer the formulated research questions, this article applies bottom-up methodology in line with grounded theory and analyzes real-world examples of soundscape-related measures contained in the CSI to deduce a theoretical framework that enables a differentiation between concepts and practices. It aims to summarize relevant findings and highlights lessons learned from developing a taxonomy. We critically discuss nomenclature, revisit and amend the term "soundscape intervention" and introduce a qualitative distinction in the form of a design pyramid to differentiate between sonic installations and sonic interventions, and between interventions, which have been planned and executed following a design process in line with the ISO/TS 12913 series [36–38], as opposed to more informal implementations, which are commonly observed among practitioners outside the academic and research field.

2 Methods

In the absence of an established soundscape design process model to draw on for the development of guidelines, as the model is still in development, the question arises how to methodologically proceed to formulate guidelines. A deductive, top-down approach, based on existing recommendations found in the ISO/TS 12913 series and academic soundscape literature, would ensure that the resulting soundscape design process aligns with larger objectives. However, the lack of pragmatic, real-world references may yield an idealized version of what soundscape design should entail, which does not necessarily correspond to how soundscape-related measures are carried out in real-world settings. Therefore, a grounded theory approach [39] may be better suited to generate new insights by retrieving and synthesizing empirical evidence from currently implemented soundscape-related measures.

2.1 Grounded theory in soundscape research

Grounded theory is becoming increasingly popular in soundscape literature with many scholars adopting such a methodological approach in qualitative soundscape studies (see, for instance, previous studies [40–43]). Grounded theory uses inductive, bottom-up reasoning to construct a model or theory through the collection and analysis of relevant data [44]. In that sense, it converges with the holistic approach of soundscape in its emphasis on understanding human experiences in context. By collecting data on implemented soundscape-related measures, it is possible to understand the practical implications of soundscape-related measures in real settings; identify recurring patterns, strategies, and challenges; and showcase best-case examples that could help build a design framework to inform practitioners.

Figure 1 shows the steps involved in the generation of a grounded theory for soundscape design guideline development, as applied in the CSI project. For this purpose, we adopted the manual coding process described in the study by Wagner and Fernandéz [45] and adjusted it to fit the present subject. The process relies on purposive, non-probability sampling and commences with data collection on existing soundscape-related measures from various sources. Open coding follows, during which the collected information is segmented and labels are assigned to each segment to facilitate interpretation. Subsequently, axial coding ensues, during which connections and dependencies between segments are drawn. In selective coding, the initial codes are refined, condensed, and merged into core themes. This process

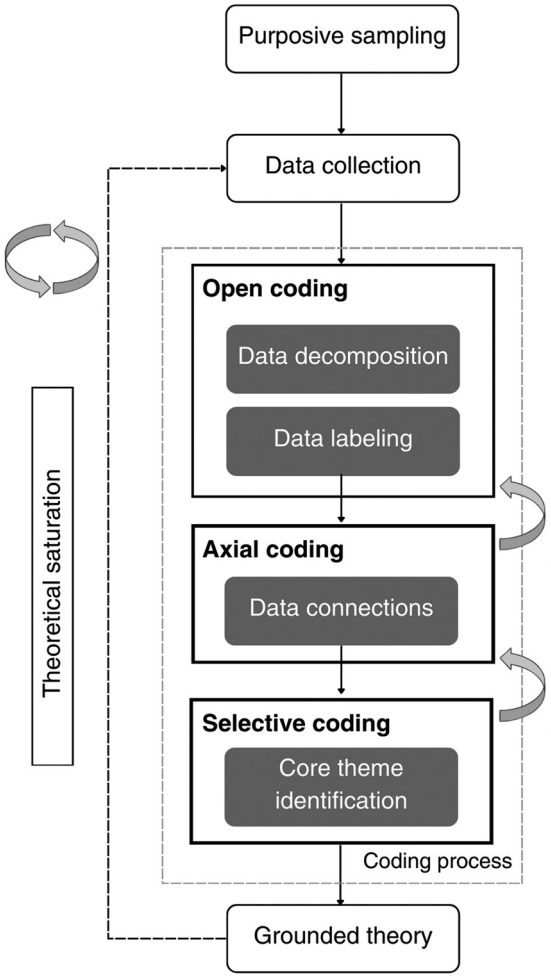

Figure 1: Coding process to derive a grounded theory for soundscape design guideline development, adapted from the study by Wagner and Fernandéz [45].

chain iterates until theoretical saturation, *i.e.*, when more data do not yield new insights or information, solidifying the concepts and resulting in a theory that is "grounded" through the collected data. The described process is not necessarily linear and may involve relapses and cyclical progression, because of the constant juxtaposition and update of data. To this end, the CSI project was initiated to continuously collect, but also to communicate comprehensive information and insights on implementations of soundscape-related measures worldwide [32] (see Section 2.3).

2.2 Existing compilations of implemented soundscape-related measures

Though the term "soundscape intervention" is often used to refer to a soundscape-related measure, the absence of

guidelines has led to some uncertainty and debate among scholars about what qualifies as a so-called "soundscape intervention" to begin with and what the purpose of a "soundscape intervention" is. Currently, it is unclear how practitioners of soundscape within and beyond the research and academic context interpret the concept of a "soundscape intervention." To understand how soundscape-related measures translate into practice and what goals they pursue, it is therefore necessary to look at real-world examples. However, documentation on this subject is quite scarce, rarely circulates outside the academic context, and does not seem to frequently appear in urban planning and design literature.

Assorted examples of implemented soundscape-related measures have been included in reports issued by governmental institutions [46,47], in collections highlighting the applicability and general benefits of the soundscape approach for urban development [48], and in research articles and publications discussing selected case studies [49,50]. A more extensive collection is found in online repositories, such as "urbanidentity," by Trond Maag [51] or "Soundscape Design," a collaborative project initiated by Gunnar Cerwén and the think tank Movium [52]. Given that these compilations are partly already over a decade old and that information on this subject has not been centralized in a dedicated, openly accessible inventory, which is easy to navigate and filter and which enables all practitioners to contribute to equally, the CSI was initiated.

2.3 CSI project: toward a taxonomy of soundscape interventions through grounded theory

The CSI is an online repository [53] that is openly accessible to the public, thereby encouraging transparency and participation for practitioners outside the academic and professional context. To collect data on existing, implemented soundscape-related measures, the CSI adopts a systematic approach by introducing a protocol, which all contributors must fill out prior to submitting implemented soundscape-related measures. For the purpose of brevity, such measures are henceforth also referred to as "projects," "examples," or "cases." This protocol aims to harmonize data collection, facilitates comparability, and encourages clear documentation that facilitates better comparison. It also serves as a reference point. The protocol requires contributors to submit the name and exact geographical location of a project; provide information on the data and status of its implementation (ongoing, temporary, permanent); list initiators, involved participants, and the typical audience. While this information can be specified from the predefined options, free text fields are used to describe the project and outline applied strategies in more detail. Next to this mandatory information, contributors can also elaborate on possible observations after the completion of the project, share project documentation, and upload audiovisual material.[1]

After an initial screening, checking for potentially harmful content or copyright infringements, submitted cases are reviewed based on a criteria identification checklist (see the study by Moshona *et al.* [32] for more details) and, after successfully passing the review, are featured on the website, each case receiving a dedicated page. To commence the process and offer some orientation to contributors, some cases were submitted by the CSI project team. These cases were derived from various sources, including government and non-governmental organization reports, academic publications, and online articles. To a certain extent, they, therefore, overlap with cases reported in previous compilations.

During open coding, cases were manually reviewed and free text entries were segmented and annotated, using distinctive labels. This enabled structuring the data, drawing connections, and uncovering dependencies during axial coding. Subsequently, in selective coding, these topics were scanned for redundancies and condensed into overreaching themes, which were then discussed in an expert panel. The coding process is exemplified in Figure 2 for two submission examples. This resulted in a classification scheme, henceforth called a "taxonomy." Each of the currently 43 existing cases in the CSI was then classified on the basis of the derived taxonomy by two individual researchers, who engaged in extensive communication, until a consensus was reached. This ensured consistency and accuracy, while also uncovering interpretative ambiguities.

3 Results

The aim of this section is twofold. First, it aims to summarize findings from existing compilations of soundscape-related measures and to identify knowledge gaps, as well as potentially emerging problems and limitations. The overview does not include single case studies. Second, it describes the resulting taxonomy and compares outputs to

1 The full submission form is available on the CSI website: https://soundscape-intervention.org/submissions/

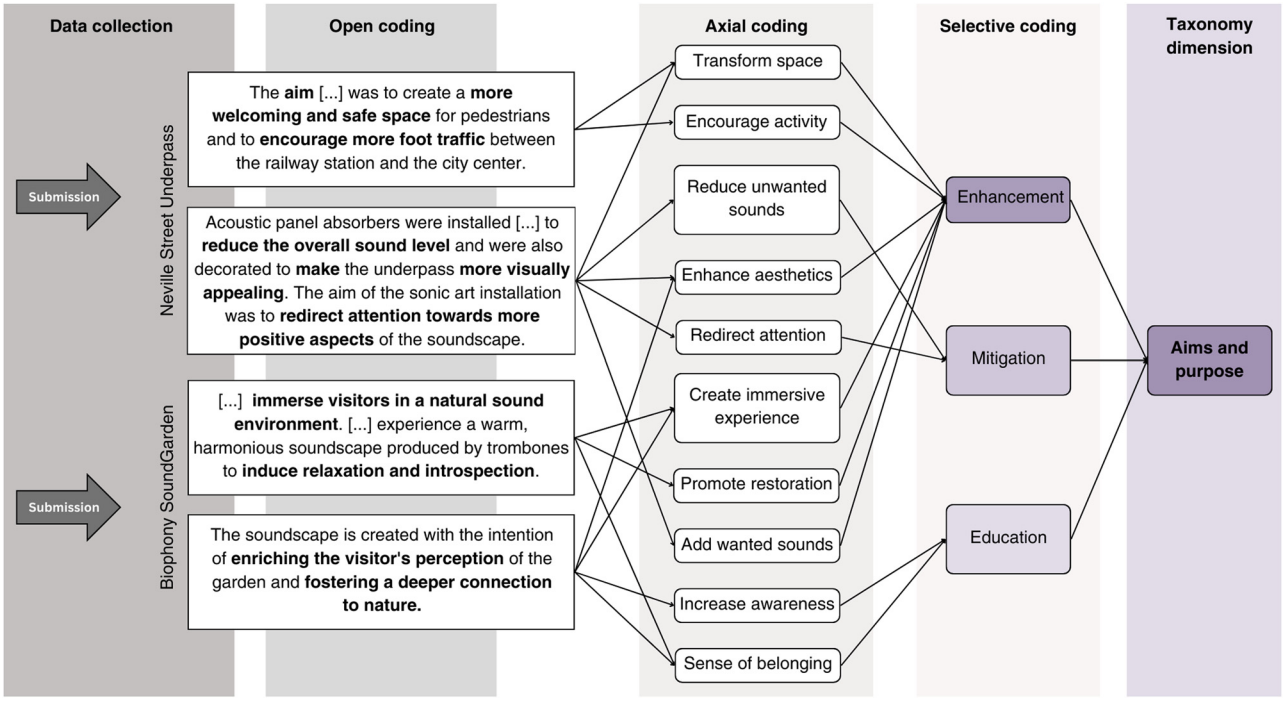

Figure 2: CSI coding process example based on text snippets from two submissions (Neville Street Underpass, Biophony SoundGarden), illustrating the derivation of core themes which lead to the taxonomy dimension "*aims and purpose*" (see Section 3.2). From left to right: segmentation and labeling in open coding, data structuring in axial coding, and thematic condensation in selective coding.

the insights gained by reviewing existing compilations in terms of similarities and potential differences.

3.1 Findings and limitations of existing compilations of implemented soundscape-related measures

According to the compilations listed in Section 2.2, soundscape-related measures seem to be applicable to different types of land use, including urban civic spaces, urban residential areas, urban green spaces, and recreational areas and "*range from artistic interventions, to council, policy, and consultancy interventions*" [46]. Measures span from micro to macro level, in terms of both area coverage (individual street or park *vs* larger residential area) and outreach (case study *vs* master plan for the future development of a city), with cities taking increasingly more proactive approaches to manage local soundscapes [48].

The examples in these compilations paint a very heterogeneous picture in terms of their rationale. Frequently, the purpose of a soundscape-related measure is to improve or preserve the *acoustic quality* of an environment, typically affected negatively by traffic noise [46]. This rationale highlights the need for restorative spaces in urban environments. However, non-acoustic incentives may also exist, which use soundscape methodology as a means for better placemaking. These incentives encompass societal, cultural, infrastructural, and economic dynamics, such as preventing alienation or disconnection, bolstering local character, encouraging engagement, discouraging antisocial or territorial behavior, broadening access for varied groups, or enticing tourism. In addition, exploring phenomenological aspects of soundscapes is often the driving factor among artists. While some projects prioritize holistic considerations from the start, others focus on altering the physical environment through functional design alterations [46]. Interestingly, creating a sense of ownership or control over a situation is often a motivational byproduct of a taken measure [50], which does not necessarily align with the aims of restoration or placemaking. Notably, the rationale of some measures described in the referenced compilations is unknown or at least not clearly documented. Regardless of the motivation though, it seems that the central objective across the examples rarely centers solely on reducing sound levels.

Usually, different approaches are employed to manage and enhance soundscapes, including assessment methodology, noise control, and sound incorporation through

artistic installations, integration of natural elements, or the utilization of pre-existing sounds [48]. A manual containing 23 "soundscape actions" on how to translate these somewhat abstract concepts into practice is provided by Cerwén *et al.* [54]. This list of actions is sorted around three main categories:

(1) localization of functions,
(2) reduction of unwanted sounds, and
(3) introduction of wanted sounds.

This work is a rare example of hands-on information for practitioners on possible ways to integrate soundscape concepts into urban design and planning. However, despite its novelty and value, it does not include an explanation of when certain actions are indicated or an evaluation of which actions work best in which contexts. It could therefore be compared to an inspirational "palette" to pick from.

Strikingly, very few of the reported case studies in the referenced compilations have evaluated the success of the measures taken and even less have undergone a formal evaluation. It would seem that the focus is frequently on the action itself, rather than on pre- and post-considerations. The reasons for this are unclear, but could be owing to limited, project-related resources or a general uncertainty on how to plan and evaluate a measure.

In addition, heterogeneous vocabulary is used to refer to the soundscape-related measures, including "*soundscape designs*," "*(design) interventions*," "*soundscape interventions*," "*(applied) soundscape practices*," "*soundscape projects*," "*soundscape actions*," "*purpose-driven soundscape designs*," "*projects achieving good acoustic quality*," etc. In some cases, a qualitative distinction is made, but in others, the terms are used interchangeably. Furthermore, it is sometimes unclear by what criteria examples were selected to be included in the referenced compilations. In general, the reported examples seem to always align with the scope of the underlying publication. This is understandable, but it increases bias in the sense that other cases, which do not fit the scope of the publications or which do not tell a "success story," may be overlooked. The cases listed may therefore not be representative of the greater picture.

Though a few of the referenced compilations provide a meta-analysis of the implemented soundscape-related measures, addressing their rationale, describing the strategies used, and evaluating the results whenever possible, the presented information varies in completeness, detail, and the degree of systematicity, making comparability between case studies difficult and the extraction of information effortful. This underlines the need for a more systematic approach, which we adopted when deriving the CSI taxonomy, as described in Section 2.3.

3.2 Taxonomy dimensions, distributions, and observations based on the CSI dataset

The eight dimensions of the taxonomy resulting from the coding process described in Section 2.3 and their corresponding manifestations (A–E) are as follows:

(1) *stages*,
(2) *contributors*,
(3) *scale*,
(4) *period of time*,
(5) *intervention types*,
(6) *public involvement*,
(7) *aims and purposes*,
(8) *approaches* (see Table 1 and Figure 3).

These dimensions incorporate already existing classification schemes, but also novel aspects, derived from the

Table 1: CSI taxonomy dimensions (stages, contributors, scale, period of time, intervention types, public involvement, aims and purposes, approaches) with their corresponding manifestations A–E, according to the study by Chen *et al.* [35]

Dimension	Manifestations				
	A	**B**	**C**	**D**	**E**
Stages	Planning	Implementation	—	—	—
Contributors	Urban planners and architects	Acoustic engineers	Musicians/artists	Academics	Policymakers
Scale	Micro	Meso	Macro	—	—
Period of time	Short-term	Permanent	—	—	—
Intervention types	Source	Path/infrastructure		Design/integral	Receiver
Public involvement	Formal application	Design/management	Implementation	Assessment	Dissemination
Aims and purposes	Preservation	Enhancement	Mitigation	Design integration	Education
Approaches	Architectural	Mechanical	Electroacoustic	Biological/natural	

underlying data. While "*stages*," "*scale*," and "*period of time*" are singular in nature, the remaining dimensions are plural, meaning that one case can have different manifestations of the same dimension. Given that the taxonomy is a product of a dynamically growing body of evidence, it may need to be revised in the future. It should therefore be understood as a first attempt at classification, rather than an exhaustive, finalized framework.

The dimension "*stages*" categorizes cases, based on whether considerations about the resulting soundscape were integrated during the planning or implementation phase of the project. This classification operates under the assumption that planning and implementation are distinct temporal phases of a soundscape design process, and that it is therefore possible to decouple them. This distinction is commonly made in architecture and urban planning, but may not necessarily hold true for practitioners of soundscape outside these professional fields. As can be seen by the distribution in Figure 3, the overwhelming majority of cases in the CSI catalogue fall under "implementation." This may be an indication of a strong focus on the practical realization of a project, but may also be a symptom of lacking guidelines and existing hands-on tools on how to integrate soundscape concepts in the early phases of urban planning and design.

The dimension "*contributors*" refers to the parties involved in a project, from the initial conceptualization to the actual implementation and evaluation. Several stakeholders and a variety of professional fields are included in this category, stressing the importance of multidisciplinary perspectives. Acoustic engineers are involved in almost all of the recorded CSI cases and make out the

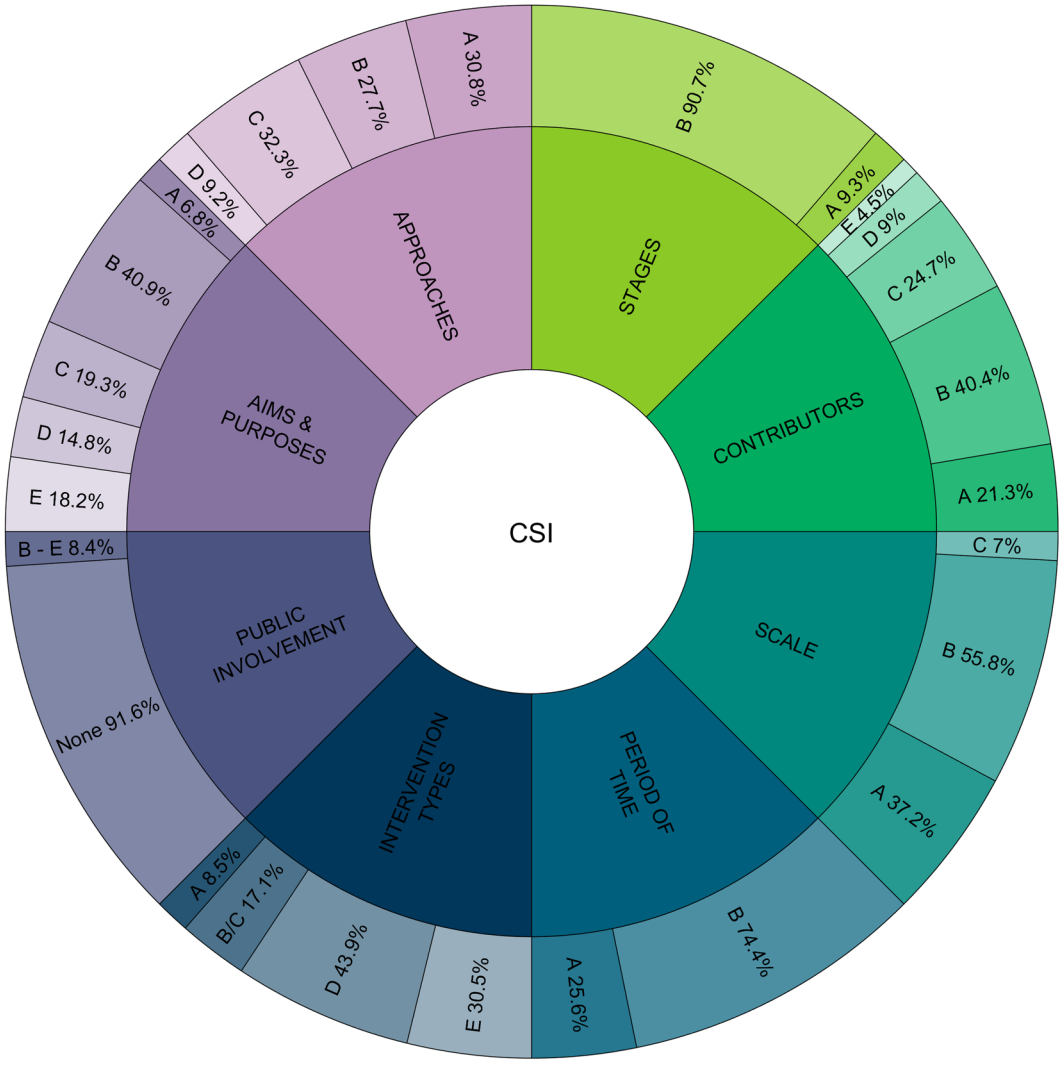

Figure 3: Taxonomy wheel derived from the 43 CSI cases, depicting the eight dimensions (inner ring) and the distribution of their respective manifestations A–E (outer ring) (Table 1). Adapted from the study by Chen *et al*. [35].

largest proportion among contributors, followed by musicians or artists and urban planners or architects. In contrast, academics and policymakers are rarely involved. Notably, residents or the public do not seem to be included as an initiating party in the recorded CSI cases.

Following common levels of analysis used in social sciences that are also applicable in soundscape [22], the dimension "*scale*" describes the spatial extent of a project. Most CSI cases are classified as meso- and micro-scale projects, with only a few macro-scale cases, which aligns with findings from previous compilations, *e.g.*, the study by Payne *et al.* [46] described in Section 3.1. Given that soundscape concepts are usually not included in national policy and action plans, with the exception of the pioneering example of the Welsh Government [25,27], this is not surprising. This may also be owing to logistical feasibility, given that smaller projects are easier to manage and communicate and their impact is more immediately felt on local levels.

The dimension "*period of time*" quantifies the timescale or longevity of a project, a distinction also made by Oberman [49]. While most projects are classified as being permanent rather than temporary, it ought to be noted that information on whether projects are being maintained and curated is lacking and that it is, therefore, uncertain whether some of the listed projects are still actively in place in their intended function. However, typically, the emphasis appears to lie on long-term impacts to the soundscape rather than short-term solutions.

The dimension "*intervention types*" defines stages and forms of possible interference in the propagation trajectory between source and receiver and has been adopted from a framework, which was originally developed for the World Health Organization (WHO) guidelines for environmental noise [55] in a slightly adapted version proposed by Fiebig *et al.* [56]. Building on already existing infrastructure, integral/design types are the most prevalent, followed by receiver types. However, the vast majority of the CSI cases is not classifiable by only one singular type of intervention, highlighting the mixed methodology used by practitioners. Notably, only a few cases are classified as interventions at the source, providing evidence that the focus is not on traditional noise control, but rather on shaping the overall soundscape and targeting the receiver's holistic experience. This confirms observations from previous reports, as outlined in Section 3.1.

The dimension "*public involvement*" was adopted from the concept of user/consumer participation in healthcare research and was slightly adapted to fit the field of soundscape [34]. The dimension captures the degree of public participation, based on different stages of possible involvement in the life cycle of a project. Only a very small fraction of the CSI cases employ public involvement, although there may be a possibility that some cases were overlooked due to a lack of concise documentation regarding this subject. In general, though, public involvement is underused, which contradicts the principles of user-centered, inclusive design and democratic decision-making in addressing community needs and preferences embodied by the soundscape approach. One explanation might lie in the fact that involving the public can be quite time-consuming and that in some cases, strict time plans or limited resources may pose a hurdle.

The "*aims and purposes*" dimension summarizes the intended outcomes to be achieved, as well as the rationale of projects. The ways by which these outcomes can be achieved align with existing design formats and "soundscape actions," formulated by previous studies ([57,58], and [54], respectively). As with "*intervention types*" and "*approaches*," this dimension can have plural manifestations. While some projects have clearly formulated aims, others are more vague and some can only be reconstructed through the given context, due to lacking documentation. In general, the focus seems to lie in enhancement, *i.e.*, improving the quality and positive attributes of the soundscape and to a lesser extent on creating new atmospheric experiences or generating subjective impulses. Preserving the qualities of a soundscape does not seem to be a frequent aim, although nearly a quarter of the listed cases are located in parks, forests, and green spaces. It may also be an indicator that unique soundmarks worth preserving are rarely found in urban spaces or that they are rarely appreciated. This dimension should not be understood as exclusively referring to the acoustic quality. The CSI cases demonstrate that other design aspects, such as community safety, character, accessibility, mobility, or environmental sustainability, may be core objectives, which is also in line with previous reports (see Section 2.2).

Although, in the current version of the taxonomy, outcomes and rationale are regarded in unison, it is worth observing that these two concepts are clearly distinct. While outcomes describe the primary aims of a project, the rationale refers to its actual purpose, *i.e.*, its inherent motivation. Outcomes and rationale may overlap, but they are not necessarily identical. Also, one project may have multiple aims, but the motivation is likely to be unique.

Finally, the "*approaches*" dimension encompasses the different acoustic design techniques applied to influence or alter the soundscape, based on their invasiveness and degree of reversibility, as introduced and outlined in our previous studies [34,35]. As with the "*intervention types*" dimension, most listed cases use combined techniques. While architectural, mechanical, and electroacoustic approaches are evenly distributed, with the latter being the most frequent

technique used among the recorded cases, nature-oriented approaches such as renaturation are rarely applied, although these approaches offer several advantages in regard to city climate and comfort, biodiversity, levels of restoration, and in terms of sustainability, due to the low energetic and maintenance costs involved. This may be explained by the fact that nature-oriented approaches require more time to unfold their impact, while other techniques are more immediate and in the case of electroacoustic approaches, logistically easily implementable and budget-friendly. It may also be an indication that nature-oriented approaches are not considered or named as possible "soundscape actions" by practitioners, even though they de facto alter the soundscape and could prove beneficial for non-human species as well. Considering the permanent nature of many CSI cases and the long-time implications they can have, exploiting ecological synergies may, nevertheless, be advisable for future work [35].

3.2.1 Relations between taxonomy dimensions

Examining the connections among dimensions more closely by, considering subsets of distributions, uncovers interesting aspects of present-day methodologies and practices. When comparing how "*intervention types*" relate to "*approaches*," it becomes evident that the approach most frequently used to influence the propagation path between source and receiver in existing infrastructure (Type B/C) are architectural modifications. This is unsurprising, given that architectural modifications often include barriers, which serve as noise control elements and direct attention away from unwanted attributes of the soundscape, both auditorily and visually. This coincides with the "*aims and purposes*" dimension, which yielded enhancement and mitigation as the primary objectives for these cases.

The picture changes and becomes more heterogeneous at the integral/design level (Type D), where architectural, mechanical, and electroacoustic approaches are evenly used in combination. Combining masking techniques with the active addition of sounds, either through natural means or through sonic installations, is consistent with the prevalent "*aims and purposes*" dimension for this type, which is enhancement.

Electroacoustic approaches dominate at the end of the pathway (Type E), as a very direct way of influencing subjective experience. The primary objective of these cases is also enhancement, which shows a strong focus on creating more pleasant soundscapes for receivers, followed by educational objectives. Often, multisensory techniques are used to trigger different modalities at once through the interplay of sonic and light features. Among the CSI cases, educational objectives relate to increasing awareness, social engagement, and promotion of social cohesion, but are less concerned with didactic aspects and individual behaviors. The outlined relations between "*intervention types*," "*approaches*," and "*aims and objectives*" provide evidence that these taxonomy dimensions influence and complement each other. They should, therefore, not be understood as independent factors.

4 Discussion

4.1 Limitations of CSI taxonomy

The derived taxonomy provides a useful orientation aid to characterize both existing and future soundscape-related measures, revealing common practices. However, it was derived from a limited dataset of 43 cases, and it is questionable whether this arbitrary amount is sufficient to uncover all relevant aspects of soundscape-related measures. As the CSI repository grows, the taxonomy is likely to be updated and potentially extended to include other dimensions. For example, information on funding or on types of land use may be helpful additions.

One general limitation of the CSI repository is that it currently only contains cases from the Global North, which narrows its diversity. In addition, the represented countries often have clearly formulated environmental policies, supporting structures and funding possibilities, which may not necessarily apply to other regions. They also often share a network of soundscape communities, which may influence the way soundscape-related measure are carried out, because of the said situational premises. The derived taxonomy may, therefore, not be representative of practices beyond these regions. Hence, it is crucial to intensify efforts to rectify this uneven distribution.

4.2 Revisiting the definition of "soundscape intervention"

The taxonomy derived on the basis of "grounded" data, *i.e.*, real-world implementation of soundscape-related measures, unveils the heterogeneity of the projects contained in the CSI repository on multiple dimensions. This prompts the need to revisit the essence of a "soundscape intervention," calling for terminological reflection – even within our own work – in an attempt to explain and perhaps reconcile potentially differing views.

In the context of our previous works [34,35], a soundscape intervention was understood to be "*a site-specific design, aimed at preserving or improving an acoustic environment*." This description was adopted from a preliminary document released by the ISO working group 54 (ISO/AWI TS 12913-4), which is still under development [31]. The proposed definition highlights three important aspects: (a) that a soundscape intervention is tailored to the needs of a *specific site*, (b) that a soundscape intervention has an actual *aim*, and (c) that this aim involves either *preserving a desirable status quo* or *improving* the acoustic environment. Though not explicitly stated, the definition also insinuates the existence of a prospective threat to and/or an actual problem within the acoustic environment that triggers the need for preservation or improvement. In that sense, an intervention can be regarded as a recovery measure or a measure to prevent further damage to the acoustic environment. Evaluating its success requires a pre- and post-comparison of the soundscape before and after the intervention.

The ideas and concepts of the proposed ISO definition are partly rooted in the linguistic origins of the word "intervention," but are foremostly derived from early soundscape literature. The Oxford English Dictionary [59], following the etymology of the word "intervention" (Latin: "intervenere"), defines it as follows:

> **intervention**, **n**. *The action of intervening, "stepping in," or interfering in any affair, so as to affect its course or issue.*

This definition mirrors the everyday use of the word, which is understood as a purposeful interference by an external force to steer the course of an affair to a preferred direction and is used in various domains, including sociology, politics, psychology, and healthcare. The Oxford definition neglects to make a reference to maintaining or promoting a preferred state. Conversely, the Cambridge Dictionary [60] includes this aspect of conservation and/or amelioration and furthermore stresses the intentionality of the act:

> **intervention**, **n**. *The action of becoming intentionally involved in a difficult situation, in order to improve it or prevent it from getting worse.*

Transferring these strictly linguistic conventions to soundscape design, they infer that an intervention is a deliberate, *active change* to the acoustic environment, initiated by an outward party. It is, therefore, not just an intention, but rather the factual realization of an intention, mirrored in the design plan [61], which, according to the proposed ISO definition, pursues the goal of preservation and improvement of the acoustic environment. However, the aforementioned definition offers no suggestion on how to actually achieve these goals and what exactly they entail.

Often, the notion of preservation and improvement aligns with Murray Schafer's understanding of acoustic design. According to Schafer, the aim of acoustic design is to "*[...] discover principles by which the aesthetic quality of the soundscape may be improved*." This can be achieved through the "*elimination or restriction of certain sounds, ... the preservation of* [unique] *sounds (soundmarks) and above all the imaginative placement of sounds to create attractive and stimulating acoustic environments* [62]. These somewhat loosely formulated recommendations were later translated into actual design strategies [57,58] and are commonly referred to as "minus design," "preservation design," and "plus design" [61]. Minus design involves traditional noise abatement principles, such as buffering and mitigation techniques and noise reduction at the source. Preservation design entails identifying and preserving sounds that deserve to be maintained, *i.e.*, sounds that contribute to a sense of place and identity. Finally, in plus design, positively associated sounds, often natural and biophonic elements or sounds of social and cultural importance, are added to the acoustic environment. Simultaneously, these sounds can be used to mask unwanted sounds.

Although the aforementioned triptych of design strategies is widely spread, as mirrored by the recorded CSI cases, and is also partly reflected in the international standard, it should not be interpreted as being exclusive. It is, therefore, conceivable that other ways to preserve or improve the acoustic environment may exist that are currently not accurately represented.

4.3 Amending the term "design interventions"

The proposed ISO definition focuses on the *outcome* of a soundscape, or more generally, a design intervention. However, beyond the field of traditional soundscape literature, the motivation for a design intervention is not necessarily always teleological. This means that the purpose of an intervention is not primarily determined by its results, *i.e.*, preservation or improvement of whatever construct is of interest. In experimental design, a design intervention is seen as a research method to "*enable new forms of experience, dialogue and awareness about the problematic to emerge.*" [...] "*The immediate objective is not so much to arrive at closure, as it is to prompt reflections about the*

issue in discursive contexts" [63]. In this context, a design intervention is a form of inquiry, motivated by the value of the action itself and therefore deontological in nature.

Similarly, in urban interventionism, the goal of an intervention is to foster critical discourse about the urban built environment, raise awareness on social issues, involve local communities, and inspire changes for the common good [64]. The focus is not on evaluating these changes, but on prompting them. Urban interventionism is a collective name given to activist design and art practices, which are usually small-scale and temporary in nature. These interventions are understood to be "*actions, performances, installations and objects created by artists, and/or activists and sometimes architects, and inserted into, or responsive to, everyday urban environment*." [65].

Though all three introduced definitions have, in common, that they address a "problem" in the broader sense, their inherent motivation and the way by which the value of a design intervention is measured seems to be different: in the former, the focus is often on the outcome, while in the latter two, it is in the process itself. This shift in focus is not trivial, because it inevitably influences the way a design intervention is received and evaluated. If the focus is on the ameliorating outcome, then the question arises if it is possible to achieve an amelioration, which is collectively regarded as one. This aspect is particularly important when the design intervention takes place in public space, addresses the so-called "sonic commons" [66] and has to accommodate the preferences and interests of a heterogeneous crowd, or even species. If the focus is on the process itself, one must ask how generated impulses can be sustainably integrated into the design intervention and consolidate into a knowledge basis to tap upon. In the CSI repository, both process- and outcome-oriented cases are represented. Given the diverse groups of soundscape practitioners evidenced by the taxonomy, it is important to acknowledge the merit and value of both mindsets.

4.4 Toward a qualitative distinction of design strategies

Conceptual differences, as introduced in Section 4.3, and diverse rationales, as described in Section 3.2, inevitably impact how designs are executed. Next to these rather theoretical considerations, logistic and situational factors may also influence the life cycle of a design. In the CSI, no qualitative distinction is made between the recorded cases, in the sense that so far, we have used the term "soundscape intervention" as an umbrella term to identify and accommodate all practices. However, in order to formulate guidelines and make recommendations on how to integrate soundscape strategies in urban planning and design, such a distinction might prove helpful.

Relying on the insights gained through the CSI project, we therefore propose a differentiation of design strategies, based on varying levels of epistemic rigor (see Figure 4). Epistemic rigor relates to the degree by which knowledge gained through diverse practices is empirically validated. Toward the tip of the pyramid, the number of projects applying such validating strategies decreases. Currently,

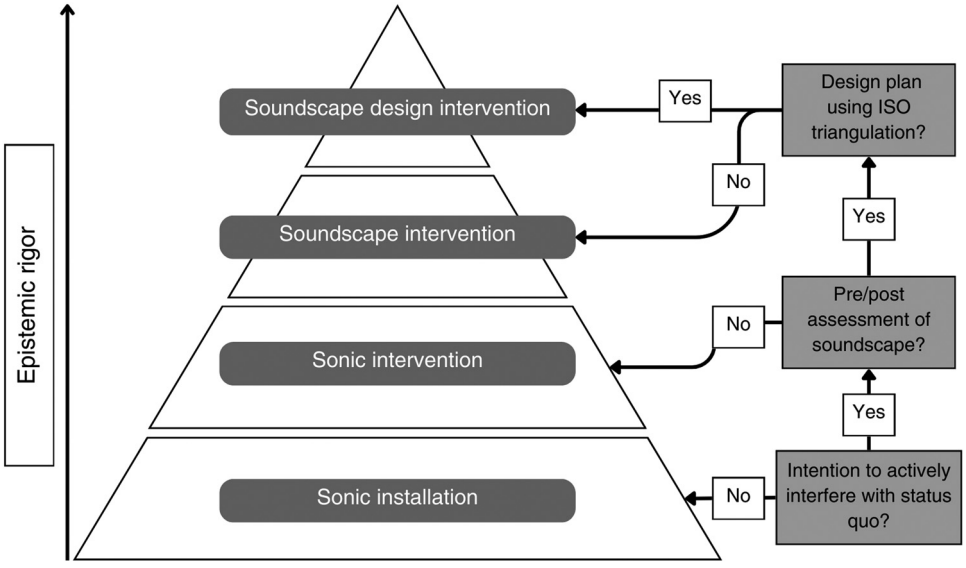

Figure 4: Pyramid of design strategies, to be read from the bottom to the top. Own illustration.

only about 10% of the documented cases fall into this category. This is mirrored in the results of the taxonomy, given that only a small fraction of the recorded projects include contributors from the academic field, who are primarily concerned with this type of validation.

As outlined in Section 4.2, an intervention is characterized by the intention to actively interfere in a situation, *i.e.*, to disrupt the *status quo*. This includes preservative measures. If such an intention is present and the interference manifests through a sonic medium, we propose the term "*sonic intervention*." If no such intention is present, but the sonic medium is used, we propose the term "*sonic installation*." Notably, the outcome of such an intervention, in terms of how successful it has been, is of no particular interest at this level. If the outcome *is* of interest, then an assessment before and after the intervention quantifies whether the identified problem has been resolved, *i.e.*, whether amelioration has been reached or deterioration averted. If such an assessment is made by taking the subjective experience of the affected parties into account, we propose the term "*soundscape intervention*." In the context of soundscapes, an intervention often aims at improving or preserving the acoustic quality, but other objectives, not immediately or solely related to acoustics, such as an improvement of the overall the quality of life, may also apply. Finally, if this assessment is already included as an action point in the design plan and considers the mixed-methods approach (both qualitative and quantitative) at the very least, or the triangulation methodology, *e.g.*, as outlined in Part 3 of the ISO/TS 12913 series is formally used, we propose the term "*soundscape design intervention*." This would entail control for all the three main components: people, acoustic environment, and context.

5 Conclusion

This article extends our previous work on deriving a taxonomy of soundscape interventions, summarizing lessons learned, and providing a theoretical framework to support and consolidate the observations made. We elaborate on the use of grounded theory as a systematic, bottom-up method to facilitate guideline development, based on real-world instances of applied soundscape-related measures contained in the CSI and explain the coding process involved, which leads to the derived taxonomy.

Answering research question (1), we reaffirm findings from previous compilations of soundscape-related measures. Namely, the CSI examples are characterized by a strong focus on implementary actions, with only, few examples integrating soundscape concepts in the early planning phases of a project. Legislative issues and a lack of regulations may be a drawback for the integration of soundscape approach in urban planning and architectural practice. The focus of most projects lies in enhancing the environment as a whole, rather than concentrating on sound-level reduction and the rationales for this are multi-faceted. In addition, only a small fraction of the recorded cases seems to be concerned with post-considerations of the resulting soundscape in terms of subjective (or other) evaluation. Next to highlighting the need for hands-on recommendations and guidelines on how to assess soundscape designs, we propose that these observations may, in part, be explained through a conceptual dichotomy in the understanding of a "soundscape intervention."

Answering research question (2), we thus see two basic concepts of a "soundscape intervention" represented in the CSI: a process- and an outcome-oriented one, in the sense that in some cases, the focus seems to lie on explorative insights gained through the process itself rather than on "measurable" outcomes. This tendency might be attributed to the prevalence of practitioners from the creative fields, next to those from the built environment sector, who often seek to evoke novel forms of inquiry and phenomenological reflection. This blend of technical knowledge and creative insight generates innovative and well-rounded approaches in shaping the soundscape, mirrored in the mixed methodology applied. However, despite this heterogeneity, the inherent holism of the soundscape approach is found lacking in terms of public participation and the integration of non-anthropocentric perspectives. Nature-oriented solutions are heavily underused, despite their salutogenetic properties and long-term potential in fostering a balanced and interconnected urban environment for all species.

Finally, based on the degree of epistemic rigor applied in the cases contained in the CSI and the frequency of represented instances, we propose a qualitative distinction between practices and in terminology, illustrated in our "pyramid of design strategies." Answering research question (3), we distinguish between four levels/types of practices, which differ in terms of the degree of evaluation of the resulting soundscape and the time point during which these considerations are made. The pyramid should be understood as an objective differentiation between practices and not as a ranking. Based on this differentiation, soundscape-related measures that seek to actively interfere with a previously identified problem in regard to the environment, use the sonic medium to do so and assess the situation before and after this interference in regards to the subjective experience of the environment's inhabitants

or visitors are termed "soundscape interventions." If these aims and steps are formulated as part of the design plan and scientific methodology is systematically applied, *e.g.*, as described in the ISO/TS 12913 series, the measures are termed "soundscape design interventions."

The suggested pyramid is an attempt at accommodating current practices and at harmonizing terminology, while at the same time acknowledging the existing heterogeneity in the field. We hope that it may prove helpful for the development of guidelines to promote and disseminate sustainable design solutions in regards to soundscapes by unveiling key aspects, which are worth considering during standardization.

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