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Soundscape Characterisation Tool (SCT): semantic assessment of sound quality in landscape projects

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ABSTRACT
The ephemeral character of sounds within landscapes has significance for landscape preservation, protection, and design. Sound and soundscapes are characterised by their continuous shifts and long-term changes, which are quite different to any static view. This paper introduces a semantic characterisation of soundscapes for landscape analysis, and its translation into an application for smartphones, *Soundscape Characterisation Tool (SCT)*, to expand and complement visual approaches in consultation and dialogue with stakeholders. The SCT is presented as a place-related and semantic tool and is discussed through a critical review of its practical application in three case studies linked to the Swedish Transport Administration planned works to expand either road or railway networks. Through the practical application of the SCT, this research advocates for the development of a new sonic vocabulary in spatial planning and design that seeks to engage people and make site-specific information available, understandable, and meaningful for all stakeholders involved.

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landscape analysis; landscape design; soundscapes; sonotopes; landscape characterisation; environmental impact assessment

Introduction

The ephemeral character of sounds within landscapes has significance for landscape preservation, protection, and design. Sound and soundscapes are characterised by their continuous shifts and long-term changes, which are quite different to any static view. The aural realm constitutes an ever-present character in the landscape, reflecting changes in cultural processes, such as urbanisation, compactness, or densification of human settlements, and should therefore form part of the management of different landscapes. The considerations in spatial planning and design of sounds that are generated and heard in outdoor environments challenge traditional visual modes of thinking that dominate relevant disciplines. In many projects, the visual aspects of a landscape are characterised through *landscape analysis*. A broad approach incorporates perceptions gathered through all the senses to assess the impact of a development in a landscape. This paper introduces a semantic characterisation of soundscapes for landscape analysis, and its translation into an application for smartphones, the Soundscape Characterisation Tool (SCT), to expand and complement visual approaches. The SCT was developed from 2003 (Hedfors,

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2003a; b), prior to the publication of the ISO 12913 parts 1, 2 and 3 that currently guide several research projects (ISO, 2014, 2018, 2019). SCT has the capacity to supplement the ISO, and links are made throughout the paper. The SCT is introduced through its application to selected projects defined by the Swedish Transport Administration, to demonstrate how sound quality can be evaluated through public participation.

The SCT discussed in these pages is both a place-related and semantic tool. Place-relatedness is crucial in landscape studies and in our research. For the purpose of this study, a site-specific sound environment is considered a *sonotope* (Hedfors, 2003a). Contrary to Abo Eleinen et al. (2016), soundscape is considered a subset of a landscape, which is experienced with all senses. A *soundscape* is considered an acoustic environment as perceived or understood by the communities experiencing it in context (ISO, 2014), and *sonotope quality* refers to the assessment by those communities. When considering the sonotope as the starting point for landscape analysis it becomes apparent that the *aural* and the *physical* spaces differ (*e.g.,* Ruiz Arana, 2024). Aural and physical space boundaries and transitional zones must be considered separately as the spaces seldom correspond to the same geographical area. When analysing aural space, certain aspects need to be considered, including the value and meaning placed on sounds which might vary amongst stakeholders. For instance, a sonotope that might work as an auditory refuge (a sound environment that contrasts with its surroundings, providing an acoustic complement) for certain stakeholders might not have any auditory or sonic quality for others.

Another aspect to consider in the analysis of aural space is the presence and propagation of soundmarks (Schafer, 1977), which might extend beyond territorial spaces. Soundmarks are sonic features, *e.g.,* the chime of the church bell or the call to prayer from minarets. The propagation of such soundmarks becomes significant in the definition of acoustic communities (Truax, 2001) that encounter historical aural phenomena. Entire gardens, parks, cities, and other cultural landscapes contain sonotopes with specific sonic patterns which could be articulated in a new pattern language of spatial management (Alexander et al., 1977).

Therefore, a method for the systematised semantic characterisation of existing sonotopes should be presented as a proposed key stage in planning and design. The systematic characterisation allows for comparisons between sonotopes. For the SCT, we focused on the development of a vocabulary to facilitate the process of putting words to recordings or other acoustic images, to broaden the notion and conception of sounds, to supplement dB-measurements, and to contribute to peoples' ability to express their experiences and opinions concerning local phenomena. In legal terms, it's important to express opinions in writing, and the written word often takes precedence over drawings, photographs, or recordings.

These semantic exercises aim to conceptualise the capacity, use and potential of acoustic phenomena in the design of outdoor environments. Semantic characterisation can also promote listening habits in the management of urban landscapes as it provides an accessible tool to engage stakeholders with aural environments. Stakeholders in landscape projects typically include neighbours, local businesses, planning authorities, and NGO:s with an interest in the site. The semantic characterisation method can be applied in descriptions of existing conditions, as well as in prescriptions of different options of change for the future. The approach can be compared to the *before-after technique* that is presented in landscape design by Humphry Repton (1816 [1982]). The characterisations are seen as tentative and should be criticised in a dialogue between designers and interested parties and then adjusted in accordance with the inter-subjective results. The purpose of our semantic approach was to facilitate analyses and communication of soundscape characteristics in the landscape for practical planning in the transport sector. Therefore, a method for sonotope analysis was tested as deliberate support in spatial planning, outdoor design, and environmental impact assessment (EIA).

Sound quality: beyond noise in EIA

The meaning of *noise* in traditional acoustic studies and in the transport sector, is twofold: as undesirable and unsafe sounds. Undesirable sounds are linked to the evaluation of certain sounds as unpleasant (*e.g.,* Morfey, 2001), and unsafe sounds to the health and well-being effects derived from sustained exposure to them (WHO, 2018). The concept of *sound quality*, as a counterpart to landscape quality that allows for a standpoint beyond sounds being appealing or not, seems more appropriate to landscape analysis, as it does not evaluate sounds as being pleasant or unpleasant (*e.g.,* Hedfors, 2003a; Hellström, 2003). In Sweden, there is a lack of proper EIA:s of noise derived from road and railway projects, as the analyses of the qualities of existing soundscapes are neglected. The aim within EIAs is to compare an existing situation (baseline) with proposed situations. Therefore, to develop a rigorous EIA there is a need for documenting the baseline situation to evaluate the effects of alternative options for interventions. The analyses of baseline situations carried out in Sweden to date are limited to capturing intensity and noise levels $L_{eq} \geq 55$ dB(A) [in some cases 50 and 60 dB(A)] from sources connected to the road or railway activities and considered to be intruding, such as sounds of vehicles. The assessment of proposals for future road or railway networks is similarly limited to the assumed noise propagation. Consequently, the assessment of the soundscape is limited to before and after comparisons of sound levels ≥55 dB generated by transportation, considered unwanted sounds. This is a limited part of the entire sonotope (Hedfors & Howell, 2011; Thiirmann Thomsen, 2009). The entire realm of sound should be documented within the baseline to determine which will be masked, distorted, or disrupted by the proposed intervention.

Without understanding the baseline of existing sound qualities, it is not possible to know which features will be affected. This, in turn, means that it is not possible to know which information, mediated by sounds, might be lost to people present in the landscape. In addition, the landscape characteristics mediated by sounds that are affected at barely measurable dB-levels (Hedfors & Berg, 2003; Kariel, 1980) will also be missed. By developing consciousness concerning the social meaning of sounds (*e.g.,* Corbin, 1998; Truax, 2001) and the landscape characteristics susceptible to noise, it is possible to easily identify and propose road and railway paths through sonotopes considered to be less sensitive.

Research aim

Landscape analysis and strategies for design are of growing importance in the transport sector. Our project sought to include the analysis of existing sonotope qualities in landscape character assessment to enhance the quality of landscape analyses in road and railway planning. Our project was designed to supplement Landscape Character Assessment (LCA), Historic Landscape Characterisation (HLC), and the Danish *Landskabskaraktermetoden* (LKM).

The aim was to develop a method to communicate sonotope qualities of significance for use in consultation and dialogue with stakeholders. Specifically, our study sought to offer a semantic characterisation of sonotopes for communication with stakeholders, thus linking with the European Landscape Convention's (Council of Europe, 2000) aim to consider the perception of everyday landscapes (*i.e.*, those accessed and experienced during daily routines) by ordinary citizens. By putting words to what can be heard, the aural world can become more comprehensible to designers, as well as to stakeholders. Wine-tasting is a good example of an activity that develops one's ability to put words to sensations; olfactory and gustatory in this case.

A parallel research project called 'Better landscape analysis for the transport sector' was carried out to guide planners in the landscape analysis process, including the characterisation of landscapes and user participation. Guidelines for both projects were produced (Berglund et al., 2013), which incorporate the outcomes of our research.

Theoretical framework

To humans, sounds act as messengers – people *understand* sounds, in a way that technical equipment doesn't. Through technical measurement such as frequency distribution and intensity, we are barely able to recognise the sources of sound or to discern what the sources might convey. Accordingly, soundscape analyses have expanded beyond technical measurements to assess (human) affective responses to soundscapes (ISO 12913 series; Welsh Government, 2023). Whereas these standards and policies capture and emphasise affective responses to soundscapes, SCT additionally seeks to study the quality and meaning behind those sounds and what they tell us about the quality of the entire landscape.

Sounds inform us about events taking place in a certain environment. Each sound includes source and a cause, and its propagation is affected by the materiality and scale of the space. For example, the chirping of a bird is clearly heard in its proximity and the detail is more distinct as it travels between reverberating buildings than in free field. Additionally, other sounds in the same environment contribute to the sonic atmosphere that colours our perception through mood-creating background sounds, and also the overall appearance of a site experienced through all our sensory apparatus. In the understanding of sound, we intuitively try to identify the possible source of the sound, and also, the action or event that has produced it. Associate Professor of information science at Aarhus University, Morten Breinbjerg (2005), states that perception is contextualised in a network of expectations and preconceptions. Humans evaluate their perceptions to decide whether any actions should be taken. In short, it is a biological skill that helps humans navigate and survive in the world (*ibid*) (Figure 1).

To embrace the intersensoriality of perception, representation of the overall appearance of a site should be expanded to include sounds (*e.g.,* Pallasmaa, 2012; Thiel, 1996). The task is to grasp the atmosphere (Böhme, 2000) through the ability to express the intersensorial experience and thereby capture the feeling, make it known to oneself, and convey it to others. Our intellectual work will become profoundly limited if we exclusively refer to information that presupposes sight and seeing (Thiirmann Thomsen, 2009).

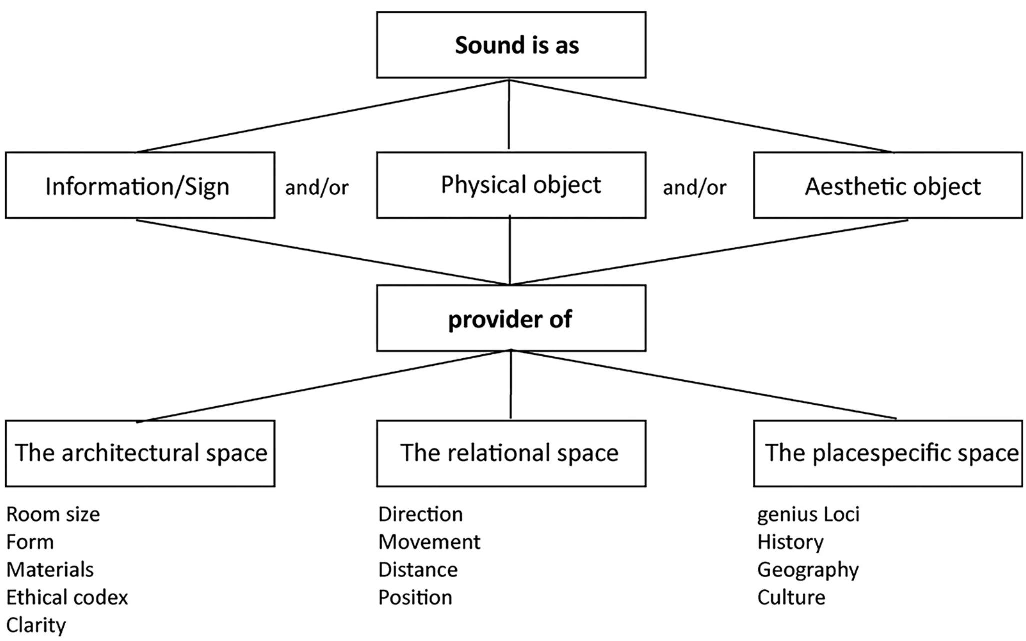

Figure 1. Perspectives on sounds indicating a need for developing a range of methods in spatial planning and design for taking those different perspectives into account (Adapted from Breinbjerg, 2005).

The societal benefits of promoting listening (Stockfelt, 1988) and gradually increasing aural awareness (Pratt et al., 1998) are associated with issues of human health (Ruiz Arana, 2024). If we acknowledged the sounds that we generate instead of discriminating against some of them, we would promote a more respectful relation to the aural realm and its impacts. If we started to develop a sensitive approach to listening, as we did during the global quieting induced by the COVID-19 pandemic (*ibid*), we could become more intimate with our surroundings – the *proximity*, as Granö (1997 [1929]) puts it. Becoming more sensitive to environmental sounds, might drive us to consider whether to continue sound-generating activities to the current extent. Thus, in many situations, our awareness might make us reduce the amount of sonic information that we produce individually and as landscape professionals through our schemes, which in turn would lead to a decrease of auditory information and a better handling of formerly stressful situations (Ipsen, 2002).

Our methodology is based on a model of communication (Truax, 2001) described as *information/signs*, Figure 1 (Breinbjerg, 2005). Sources and listeners use the landscape as an arena and simultaneously constitute parts of the scenery; they contribute to the continuous concert that we can call the soundscape (Schafer, 1977). Our methodology is also based on the *figure/ground-theory* developed in the visual realm (Arnheim, 1974 [1954]). This fits in Breinbjerg's model as *relational space*. Sound events in a sonotope are considered as figures, which stand out with varying prominence against the relatively long-standing keynote sound that corresponds to the concept of ground. The relative prominence is due to sonic characteristics, described by Gabrielsson and Sjögren (1979) as: *clarity, sharpness/softness, brightness/darkness, fullness/thinness, feeling of space, nearness, disturbing sounds* and *loudness* (Hedfors & Grahn, 1998).

The *place-relatedness* (Breinbjerg, 2005), significant to landscape architecture site theory, is addressed by Dawson (1988) when discussing *biogeographic* keynotes that exist everywhere and vary from place to place.

The model in Figure 2 distinguishes between the amount of 'figure sounds' (single events, short signal sounds that can be repetitive attracting attention) and the level of 'background sounds' (continuous, relatively static sounds that generate atmosphere but do not immediately attract attention). By seeing these in relation to two dimensions of the soundscape, namely 'perceived intensity and clarity', Hedfors (2003a) defines four distinctive and extreme types: 'clear', 'crowded', 'mild' and 'powerful'. When you hear figure sounds clearly against mild background sounds, Hedfors denotes it a clear soundscape (see Schafer's, [1977] 'Hi-Fi' soundscape). The opposite situation is called crowded (differs from Schafer's 'Lo-Fi', since many separate sounds do not automatically signify a deterioration of the soundscape, although it can be more demanding for the listener). In a mild and powerful environment, respectively, the sounds have an equal proportional relationship, but the perceived intensity in the two extremes varies (Thiirmann Thomsen, 2009). The terms clear, crowded, mild and powerful are immediately intelligible words with obvious associations. With its focus on intensity and proportionality, the Model of Prominence provides a simple tool for a general soundscape classification.

Other models for assessing soundscapes, such as the one described within the ISO 12913 protocol (2019), rely on the affective dimensions of 'pleasantness' and 'eventfulness' to characterise soundscapes into the categories of vibrant, calm, chaotic and monotonous. At first glance, the categories of calm (ISO) and mild (SCT), and the categories of vibrant (ISO) and crowded (SCT) appear to correlate. However, these categories serve different purposes. Whereas the ISO capture affective responses, the SCT additionally seeks to study the characteristics and meaning produced through sounds and what they reveal about the quality of the entire landscape. This follows approaches to landscape characterisation that are geared towards assessing differences amongst character areas and avoiding simply describing an area as better or worse than another (Natural England, 2014). The SCT can also help to address limitations of the application of the ISO. Mitchell et al. (2022) highlight the difficulty of capturing variation in time and amongst the many users of the assessed landscape through the ISO. As a response, they have developed

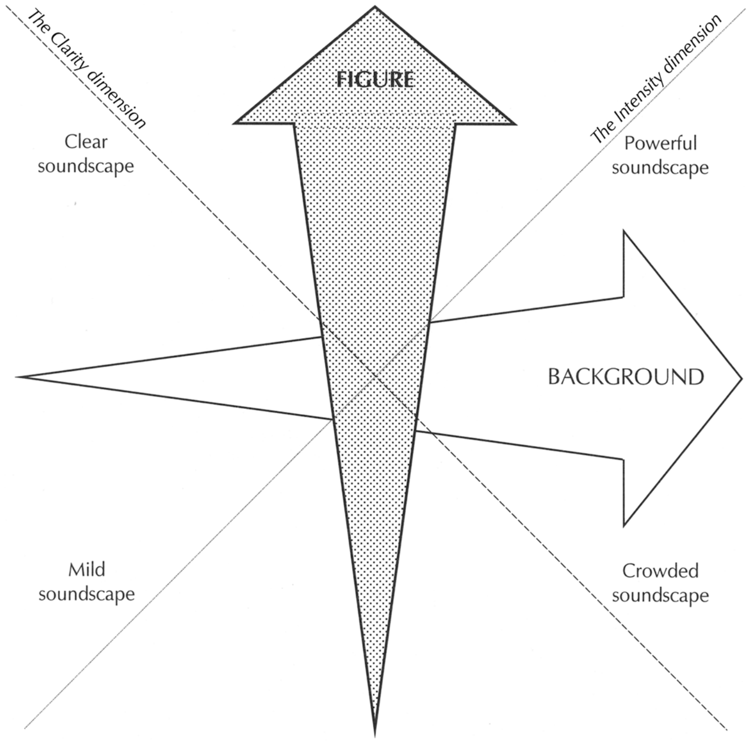

Figure 2. The Model of Prominence shows different proportions between prominent sounds (figure, events) and background sounds (keynote). The expression clarity is essentially different from intensity. Four categories are defined as: mild/powerful, clear/crowded (Hedfors, 2003a, p. 36).

an opensource visualisation tool that captures individual responses and can thus provide a more nuanced basis. Equally, the SCT has the capacity to capture nuanced responses, through its reliance on intersubjectivity, as discussed later.

Mitchell et al. (2024) identify a gap for comparing soundscape quality that considers context, aural diversity and potential design interventions. Mitchell et al. take a quantitative approach to fill this gap through the development of Soundscape Perception Indices (*ibid*.). As an alternative or complement, the SCT can provide a qualitative approach for comparing sonotope quality based on intersubjective perceptions, captured through characterisation by the existing users of those landscapes.

Despite these limitations, both models, ISO and SCT, rely on community perception and could therefore complement one another in future studies. Furthermore, the emphasis that SCT places on nuanced community understandings of sounds and their role within the entirety of the landscape, offers the opportunity to employ the tool for participatory design and decision making.

Methods

Our method of characterisation has evolved from previous methods, beginning with the above-mentioned theory of sound prominence (Figure 2). Accordingly, the method distinguishes between figure and background sounds. To characterise the sounds, glossaries for acoustic dimensions were used and developed (Hedfors, 2003a: 48; Hedfors & Howell, 2011: 35–36). Translations were carried out in English, Swedish and Danish. The protocol and corresponding

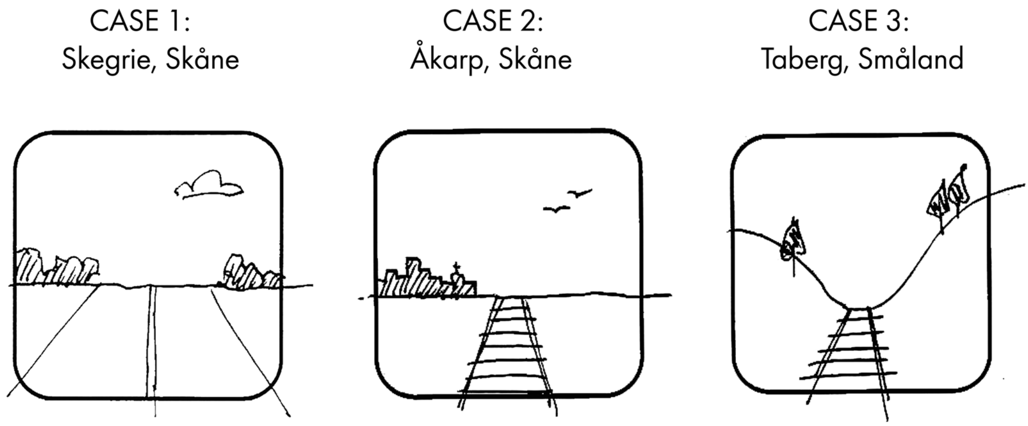

Figure 3. Case studies and topography: Case 1 is a site prior to widening and partial realignment of an existing road on flat land, Case 2 is a site prior to construction of additional rail tracks on flat land, and Case 3 is a site among other planned options where a railway could be built in sharply undulating terrain.

SCT application developed in parallel (see Figure 3), offered the user eight categories to characterise each sound in an existing or proposed soundscape. The reason for these eight categories was to introduce a slightly more articulated and tailored method for landscape architects than the Model of Prominence. These categories are more accessible for landscape architects and stakeholders than a complex sonotope syntax:

1. 'Duration' – the presence of the sound in time, whether intermittent or continuous.
2. 'Technical' – technical description of the sound, often based on classical acoustic concepts concerning strength and frequency.
3. 'Mimicry' – adjectives which partly imitate the sound itself.
4. 'Orientation' – the direction of the sound and its spatial properties: where it comes from, and whether it occurs in a linear motion, emanating from one spot or experienced as 'surround'.
5. 'Recollection' – does the sound emulate or bring to mind something else?
6. 'Source' – the actual sound source, if it is possible to hear/see what it is.
7. 'Atmosphere' – individual affective assessment of the sound depending on the feelings it evokes.
8. 'Message' – description and assessment of the meanings that the sound might convey.

The grammatical arrangement of categories in the so-called *sonotope syntax protocol* (Table 1) and the selection of words concludes with the formation of simple sentences. The collection of sentences for each phenomenon constructs a paragraph that characterises the complete sonotope. For each phenomenon, the protocol facilitates a body of one or more onomatopoeically derived adjectives (see §3 Mimicry above), which are preceded by words for temporal (§1) and technical (§2) characteristics. We use the Mimicry of each sound as the label for the phenomenon, to facilitate recognition in further processing. After these stages, the characterisation turns away from the sound itself to information about its source (§6), via spatial orientation (§4) and recollection (§5) of similar phenomena addressing what the element 'sounds like…'. From experience, there are benefits of mentioning the source in the latter part to focus on the sounds themselves and not on their sources. Moreover, carrying out explicit evaluative assessments in the latter part facilitates putting words to what is heard first in a way that will make others able to recognise which sounds are being referred to. Incorporating subjective evaluations is a statement of the researcher's opinions of the soundscape's various components, which makes the survey transparent. The different emotional characteristics (Atmosphere §7) and meanings proposed (Message §8) inform stakeholders of alternative interpretations, thus inviting them to add theirs.

The method was tested during 2010–2012 in three case studies (Figures 3 and 4) linked to the Swedish Transport Administration planned works to expand either road or railway networks. Case studies were selected from places where the Administration had long-term plans for new projects, with a view to carry out analyses before exploitation and after occupation. This paper reflects on analyses before exploitation. Of importance for landscape architects, and landscape character, is how the reflection pattern for sound propagation varies between hilly and flat terrain. Accordingly, locations with different topographies were selected. The Administration was working with routes for high-speed trains passing through heavily hilly terrain and an undeveloped valley near Taberg in the Småland highlands was chosen. The location in Åkarp is on the plain in a smaller community with existing train and car traffic alongside a frequently used route.

The Administration is responsible for both roads and railways. Therefore, a road project past Skegrie was also chosen, with special historical values, to be considered in the planning of infrastructures. The locations were visited on a couple of occasions in different weather conditions and times of the year, as our focus was not the case studies themselves but the development of SCT.

Stakeholders for these infrastructure projects typically include the municipal planning architects, neighbours and NGOs with an interest in the sites. As our involvement in these projects was exclusively geared towards developing the SCT, we did not include stakeholders.

In each case, 3–5 listening positions were selected (playgrounds, parks, pond, cemetery, *etc*.). These positions were considered to be significant to users and expected to be affected by the planned development. Each position was analysed in different seasons for approximately 30 minutes. The researcher chose a key position on the site, selected based on existing uses and landscape features, and analysed the soundscape using the protocol (Table 1). During the development of the method, it was found that prolonged listening rarely resulted in additional phenomena significant to the setting; typical of *saturation* in qualitative research (*e.g.,* Saunders et al., 2018). Key to the protocol was to develop SCT so that, when applied, sufficient information could be collected in future projects to enable proper communication with potential stakeholders and enable them to describe their experiences. In the protocol, continuous sounds are described first, which often correspond to background sounds (in Table 1: *keynotes*) followed by the most frequent or prominent figure sounds and the less frequent or prominent (in Table 1: *events*). These characterisations were made quickly and intuitively by the researcher, aided by the previous process of developing glossaries. Intuitively means capturing the immediate impression, which is possible once the researcher acquires familiarity with the method. After, the researcher can start with any category, structured according to the sonotope syntax.

Through the project, our observations contributed to the development of SCT and associated computer software to enable the application of the method to other settings (Figure 3) (Hedfors et al., 2012). After collection, semantic data is transferred to a laptop or similar device. Thus, the procedure of assembling words into sentences and paragraphs is supported by computer software (Figure 5). The data is easily restructured into comprehensible sentences to be communicated to stakeholders. If different characterisations of similar phenomena occur, they enrich the analysis, akin to visual landscape characterisation. The software has an open configuration to enable the restructuring of data following systematic syntax, or by free expression. While using SCT in the field, sound recordings can be made, aiding memory in the subsequent process of restructuring data. Equally, the SCT can be used ex-situ to explain the contents of sound recordings.

Table 1. The sonotope syntax protocol used as a support while characterising the soundscape on site.

SOUND ANALYSIS	SITE	DATE	TIME	WEATHER	NAME					
			Specification of the sound		Ljudet i sig					
MOMENT	PARTS OF SOUNDSCAPE	PARTS OF SYNTAX	Duration	Technical	Mimicry	Orientation	Recollection	Source	Emotional	Meaning
		long-term presence ↓					…sounding as…	…of…	…valued as…	telling about (proposal)
DIRECT	Atmosphere									
ANALYZE	Keynote 1									
	Keynote 2									
	Keynote 3									
	Event 1									
	Event 2									
	Event 3									
	Event 4									
	Event 5									
	Event 6									
	Event n									
	Potential sound	seldom present								
DESIGN	Proposal	not yet present								

Table 2. Example of filling in the protocol and evolving a simple sentence (Adapted from Table 1, Hedfors & Howell, 2011, p.34). However, the category 'Recollection' was not used in this instance, as seen in the table.

	Duration	Technical	Mimicry	Orientation	Recollection sounding as …	Source	Atmosphere valued as …	Meaning telling about … (proposal)
keynote	Continuous …	… polytonal and varied mix …	… of chatting, shouting and screaming …	… from all directions …	xx	… of playing children …	… valued as lively and positive …	… that tells about life, happiness and activity.
event	Occasional repeated …	… unrhythmic fade in and out …	… of swishing …	… in a specific distant sector …	xx	… of modern trains …	… valued as subordinated …	… that tells about modernity.

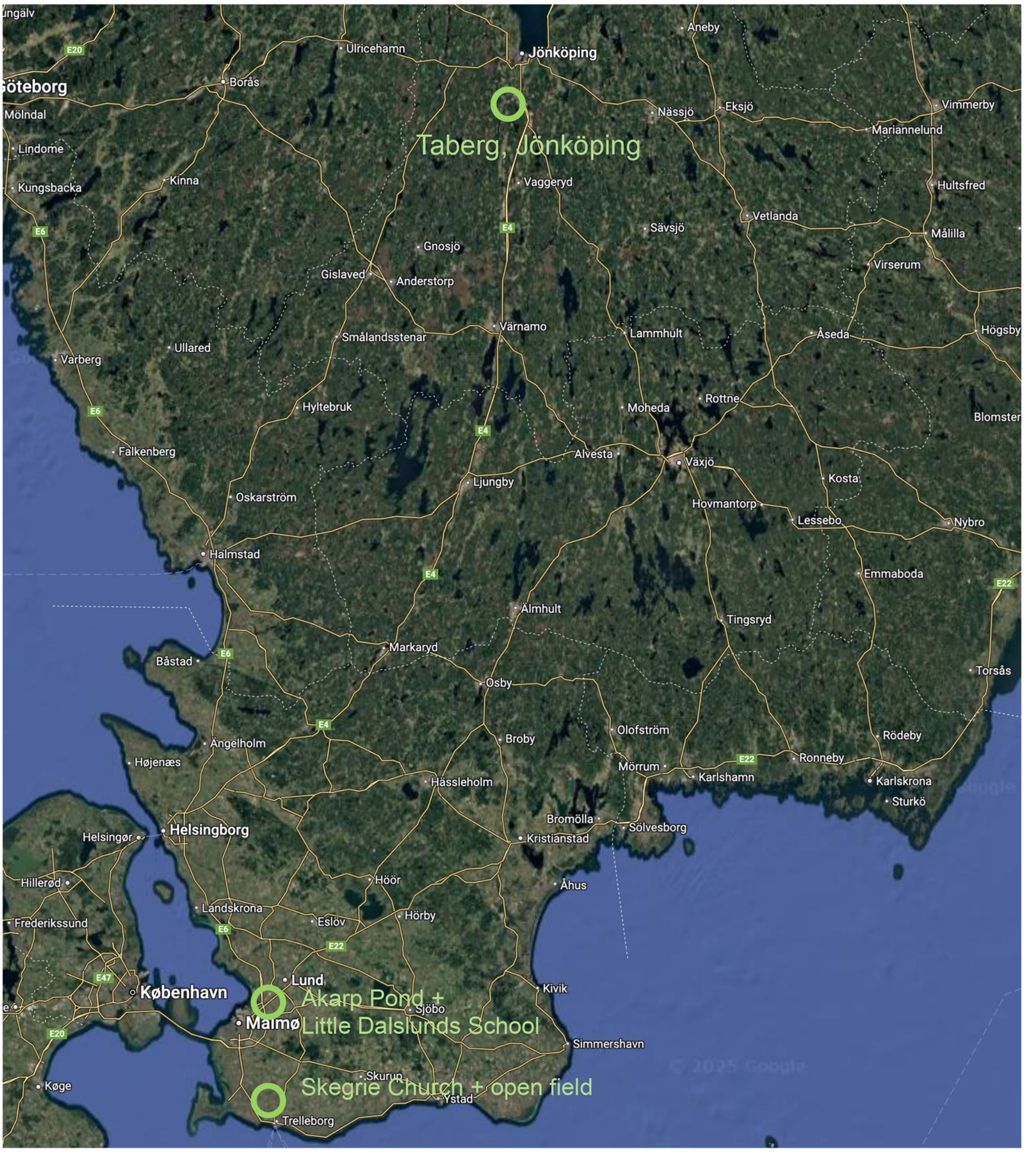

Figure 4. Location of case studies.

Results

In the following section, we present a few examples of the outcomes from the application of the protocol or corresponding smartphone application (SCT). Some characterisations might be perceived as rudimentary; however, they are accessible and demonstrate how SCT can be used and set against the non-existent characterisations that currently dominate in EIAs. The development of SCT could be further studied (Hedfors et al., 2012). First, we present an example of the outcomes of gathering data from one sonotope (Case Study II) using the entire protocol. Second, we compare one single phenomenon (that is, a part of the soundscape) at the same site from different observations (Case Study II). Third, we conclude with a comparison summary of Case Studies I, II, & III.

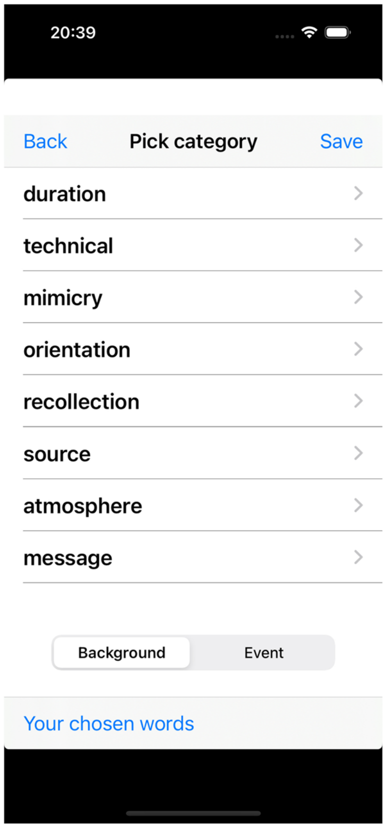

Figure 5. The operational introductory page of SCT as a prototype that could be scrolled to see the eight categories confirming the specified method, which generates the sonotope syntax.

The entire protocol, Case Study II: Åkarp pond

For Case Study II, we present the first outcomes of data gathered at Åkarp pond using the entire protocol. We present the most complex and varied sonotope only due to the quantity of phenomena it involved.

23.09.2011 at 1 pm, rain

1. Underlying keynote of a continuously modulating, strong, consistent sighing sound from highway traffic. The sound emanates from areas in front of us and disturbs us by masking our speech.
2. Prominent, continuous stream of melodic, sequenced and rhythmic beeping, chirping, and singing of small birds. The sound comes from all directions and gives a sense of vibrancy.
3. Recurrent mild, quick and rhythmic elements of the sound of dripping and tapping of raindrops against plastic. The sound is proximate, emanates from all directions and is pleasing (note the explicitly evaluative component placed at the end of the characterisation).
4. Recurring, rather short, monotonous and linear figure. It is the sound of a rumbling train approaching from the front. The sound fades in and out.
5. Recurring, rasping and rhythmic sound events of laughing, rapping and quacking ducks. The insistent sound comes from the front and left.

6. Regular (on two occasions) motorised, whirring sound, of cars on the routes behind us.
7. Temporary sequence of rhythmic, hollow resonating sound, pounding/throbbing strokes of broken branches hitting a tree from the right.
8. Single sequence of rhythmic, powerful barking from a dog from the left.
9. Temporary rhythmic and sonorous sequence of old tinkling, ringing warning bells of a traffic barrier at a railway crossing from the left. Perceived as a warning but familiar and pleasant.

This example is reported in nine numbered paragraphs. The aim was to connect the sentences and construct one single paragraph characterising the sonotope as a whole. While using the SCT (Figure 5), this procedure is supported by computer software (Figure 6). The category *Recollection* was seldom used, as the researcher was often able to recognise the source and no longer needed to associate further.

Seasonal observations of single phenomenon, Case Study II: Åkarp pond

Next, and once again for case study II, we present an example of comparisons of one phenomenon over the seasons: perception from the highway at the same site on four occasions. We chose to present this as it was present at every observation and always affected the situation.

15.09.2010 at 11.45 am, sunny, humid, moderate wind

Continuous and prominent keynote that varies at low frequencies. A sighing murmur that sounds like motor vehicles remote from the listening position. Perceived as solid and indicative of heavy traffic.

26.02.2011 at 12.30 am, sunny, clear weather, minus 6 degrees Celsius

Continuous keynote that is weak, mild and sighing coming from the front and the left, of traffic.

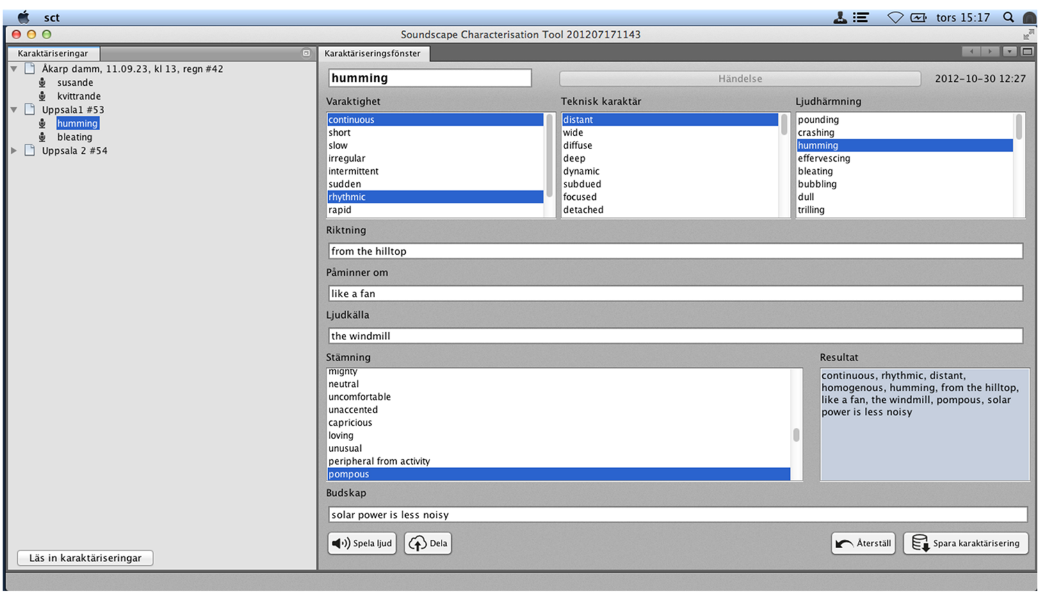

Figure 6. Computer software for restructuring data transferred from SCT after observation. Keywords and fragmentary phrases were transformed into complete sentences in logical sequences based on the sonotope syntax.

02.06.2011 at 11.30 am, sunny, clear weather, slight wind, 20 degrees Celsius

Continuous keynote, which is a distant, resonating and heavily hissing, roaring, thunderous sound of traffic coming from the front. Perceived as disturbing.

23.09.2011 at 1 pm, rain

Underlying keynote of a continuously modulating, strong, consistent sighing sound from highway traffic coming from the front.

Disturbing

In three of the observations, the sound of the traffic on the highway was perceived as solid/prominent/heavy and/or intrusive. What distinguishes the sound on 26.02.2011 from the other observations was the presence of an adult and two children skating on the pond eagerly chatting and laughing. One can therefore assume that figure sounds, in the form of talk and laughter, either drowned out the sound of the highway, or redirected the listener's attention. However, figure sounds which are defined as short seldom drown out background sounds. Therefore, one may presume that the listener's attention was redirected in this case.

Summarising the characterisation of: Case Studies I, II, III

The following paragraphs summarise the characterisation that emerged at each case study. The summaries do not follow the syntax developed for the protocol.

Case I: The flat landscape of Skegrie and the sonotope were both experienced as very open and exposed to the wind. A small creek through the village generated faint sounds of water that could be heard while passing the bridges alone. Most sounds were experienced as mild. The specific cultural heritage at the site (Jacobsson, 2007) was not perceived sonically. In wintertime, the snow seemed to emphasise the sounds of cars depending on the consistency of the snow. The figure sounds seemed more prominent. At other times of the year, the fields partly absorb motorised sounds.

Case II: The selected listening positions in Åkarp were characterised by low-rise buildings. Accordingly, the sonotope was neither considered open as in Case I, nor distant as in Case III. See further results from Case II above (see further investigations on noise in Åkarp: Mattsson & Thorsson, 2006).

Case III: The sounds were perceived as distant and long-lived, up on the hill of Taberg. They were fading in and out for a long time clearly heard, due to the topography and absence of landscape barriers that facilitated propagation. The sonotope was experienced as less influenced by human-made sounds compared to Case I and II, and was considered both desolate and pastoral, but still pleasing. Sounds typical of nature were proximal.

Discussion

Our research aimed to develop a method to communicate sonotope qualities of significance with stakeholders, with applications to all stages of a landscape projects (see Figure 7). In future planning projects, stakeholders should be encouraged early in the process to share their experiences. This approach offers an opportunity to interpretively investigate proportions between the sounding elements and their counterparts, and to articulate them. It can bring to the fore phenomena that occur sporadically and are known to the stakeholders but not to a planner or other experts, who only visit the site occasionally. Presenting the expert's subjective characterisation to stakeholders, makes it transparent, and enables stakeholders to criticise it, and to add significant elements. Additional observations can be carried out based on stakeholders'

BASELINE ANALYSIS				DESIGN
1. Identification of listening positions, of significance to existing users and that might be sonically affected by planned development.	2. Sonotope characterisation using SCT protocol by researcher at identified listening positions for 30 minutes through different seasons in-situ.	3. Refinement of sonotope characterisation/quality with stakeholders in all listening stations (in/ex-situ).	4. Analysis of how proposed development (i.e. roads) might affect existing sonotopes and idenfitication of 'sensitive' sonotopes.	5. Design amendments to minimise/protect 'sensitive' sonotopes, for example, through re-routing of roads. Design could also involve proposals for the placement of noise abatement measures of many different kinds. But also the addition of, for example, 'natural' sounds such as vegetation belts that can catch wind or attract birds and other fauna, etc.
THIS RESEARCH				
		to be combined with		
		PRACTICAL PLANNING WITH STAKEHOLDERS AND DESIGN		

Figure 7. Application of the SCT to the different stages of a landscape architecture scheme.

advice, prioritising shared understandings over subjective decisions. Subjectivity is thus replaced by inter-subjectivity.

With regard to different procedural issues, to start with, the investigator is advised to define the spatial limits of the sonotope area concerned. Both topography and sound propagation should be taken into account. This is followed by selecting critical positions or paths for listening and reading the sonotope. In our research, we could have chosen other occasions for our observations. It is therefore advised that the investigator observes the selected positions on occasions of special interest. This could be at times when people are expected to visit the site, or when a certain sonic feature is expected to be heard.

During observation, sounds might qualify either as events, background, or as something in-between. For instance, sounds that are repetitive might form single events that are repeated, or be understood as one rhythmic event. If repetitive sounds are perceived as very mild, they may be part of the background, but the investigator might choose between describing them as single, repeated events or as an extended, rhythmic event, depending on their pace and duration.

The last category in the protocol, *Meaning,* has a very wide scope. The category allows for narratives. The investigator's subjective perspective can be expressed, or the investigator may have the ability to feel empathy with other auditory interests and stakeholders and speculate meanings of the sounds for other people. In some cases, it might be best to leave the category open until the characterisations are discussed with stakeholders, to have their opinion conveyed by specific phenomena, or of the sonotope as a whole.

The model of prominence (Figure 2) can be used for a valuation of the overall state of a sonotope, which gives a more balanced picture than decibel measurements alone, as the proportion between events and keynotes is considered. Today there are several smartphone applications that function as decibel metres, which can be useful when comparing the output results of semantic characterisation with traditional measurements. Sound recordings that support the investigators' memory are preferable, as they will work as quality assurance. Even more important is the fact that the investigator can relax while visiting the site and really concentrate on listening, knowing that the sounds are being recorded.

The output results of using the method show that single phenomena were characterised, as well as whole sonotopes, providing flexibility of application. Additionally, the results show possibilities for comparing data from different observations and cases, especially when the same syntax is used. The open character of the protocol and SCT allows for a multitude of possibilities. The ability to compare quality according to context and aural diversity, and to capture nuanced responses are key limitations of the ISO (Mitchell et al., 2022, 2024). The flexibility of application of the SCT, intersubjectivity and nuanced approach to characterisation has the capacity to overcome these limitations and could therefore offer a complement to the application of the ISO (2018).

A weakness of the SCT is that certain dimensions of sound relevant to the characterisation can be 'overheard', as the method is developed from practical experience and interviews. Therefore, there is scope for the method to be further developed. However, the SCT step of creating inter-subjective characterisations with stakeholders validates the proposed procedure.

With regards to the development of the SCT, the protocol originally had seven categories, and an eighth, *Orientation,* was introduced during our research to capture spatial conditions. The development involved balancing open structure, sufficient guidance, and efficiency. The open character of the methodology might seem too loose to the expert. However, as experts learn to apply the method, they may skip the SCT in favour of a written protocol which allows for free notation. For the beginner, SCT is a useful pedagogical instrument, introducing the method and offering guidance. In addition, SCT is useful while gathering keywords and sentences and keeping to the syntax while transferring data to the computer software. Finally, SCT is useful when recording sounds as illustrative images that are described by semantic characterisations.

To conclude, we discuss what the characterisations convey about the *physical, relational* and *place-specific spaces* (Figure 1). Breinbjerg addresses sounds as *information* and as *physical* and *aesthetical phenomena*. All sounds contain *information* and as such are captured within the SCT by the categories of *Recollection* and *Meaning*. The *physical* aspects are captured by the category *Technical* and the *aesthetical* judgments mainly by the category *Atmosphere. Physical space* is not characterised by SCT. Instead, this is dealt with in LCA and HLA, which SCT aims to complement. However, the sounds are obviously transmitted through, and coloured by, the surrounding physical setting. *Relational space* is at the centre of SCT as it seeks to characterise proportions with the help of the figure/ground theory. *Relational space* and *physical space* are connected in the category *Orientation*. In addition to Breinbjerg's model, our syntax begins with *Duration*. This time dimension is perhaps too obvious to Breinbjerg and he doesn't address it. Another addition to Breinbjerg's model is our category *Mimicry,* used to imitate the phenomenon itself. We also add the category *Source* of sound, which may be part of Breinbjerg's physical space or just the generator of the sound. The last space, called *Place-specific space,* mirrors our entire sonotope approach, where the sonotope concept is grounded in *-topos* (Greek for place, terrain).

Conclusion

This study advocates for the inclusion of an accessible, local and dialectal vocabulary in spatial planning and design. The focus is not on standardisation but rather on highlighting what the local population values sonically. Decibel measurements, recordings, simulations, and vocabulary are suggested to be applied simultaneously and seen as complementary methods to achieve a multitude of representations, which invite and engage people and make site-specific information available and understandable to all stakeholders involved. This stands in contrast to other situations where only a few representations are in use, such as traditional dB-measurements. Through our study, we argue that sufficient information is needed to properly instigate dialogue in such a way that significant and sensitive phenomena become noticed. These aspects of the landscape would otherwise continue to be neglected.

In this research, sonotopes were mapped prior to the expansion of road and railway infrastructure. Additional practical applications and analyzes will help to expand the method and its application. These could include carrying out new observations after the completion of road and railway projects. Additional areas for research include exploring the procedure for selecting positions or paths for listening, and the involvement of stakeholders in listening. Although we expect our method to be used in design, our study focuses on the analysis of existing sonotopes and does not show the characterising of proposed sonotopes.

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