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Does it make a difference to have soundscape standards?

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Summary
Soundscape investigations remarkably gain in importance. Due to the holistic concept of soundscape there is a broad diversity of methods and tools in this field ranging from non-participatory observational methods over narrative interviews to the use of more or less fully structured questionnaires. This large variety of used methods and tools for data collection impedes the comparability of studies and the aggregation of data over different soundscape investigations to perform meta-analyses. In order to reach consensus about how to measure soundscape appropriately, a set of established and acknowledged soundscape methods and tools is needed. In this regard, soundscape standards one the one hand can stimulate discussions about pros and cons of different soundscape methods and tools and on the other hand could provide a common basis, where researchers and investigators can start from. The extensive application of standards can lead to new insights into the shortcomings and drawbacks of the standards, which can provoke necessary revisions in the future. However, in the context of the soundscape approach it might be justified to ask in general whether a holistic concept can be subject to standardization at all without violating the principle of holism.

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1. Introduction

Soundscape approach gains in significance due to its broad use in multiple applications. This was also supported by the European Environment Agency acknowledging the soundscape approach as an option for identifying and managing quiet areas in urban context [1]. Such approvals led to an increase of soundscape research and investigations, which for example is illustrated by the numerous contributions at acoustic conferences and congresses. By considering this vast amount of publications it is obvious that the concept of soundscape is differently interpreted and the applied soundscape investigation methods differ significantly. As the first international soundscape standard ISO/IS 12913-1 stated, the field has evolved differently around the world, as well as across disciplines, there is a diversity of opinions about definition of soundscape and its aims, and thus the use of the term ‘soundscape’ has become idiosyncratic and ambiguous [2]. As standardization aims to define characteristics, specifications or guidelines that can be used consistently to ensure that materials, products, methods, processes and services are fit for their purpose [3], the soundscape standardization efforts try to provide a common foundation for communication and soundscape application across disciplines and professions. For example, the ISO 12913-1 provided a soundscape definition; soundscape is an acoustic environment as perceived or experienced and/or understood by a person or people, in context [2]. Thus, this definition clarifies that the acoustic environment as the physical sound at the receiver from all sound sources as modified by the environment is not the ‘soundscape’ - it is the *perception* of the acoustics environment, perceived through the senses of a human.

It has to be remarked that an unequivocal definition providing an explicit understanding of the term ‘soundscape’ is not superfluous, since Brown et al. noticed that there [still] is not universal agreement among authors that soundscape is a human perceptual construct. Some (still) prefer to use the term as a synonym for the physical acoustic environment, that is, “the collection of sounds in a place” [4].

On the one hand, the international standard ISO 12913-1 providing a standardized definition and conceptual framework will help to reduce confusion and misunderstanding due to an

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inconsistent usage of soundscape term, but on the other hand, it might impede further discussions on definitions and concepts to a certain extent.

2. Common soundscape methodologies

Since neither established best practices nor standards exist so far how to measure and analyze soundscapes, it is not surprising that multiple data collection methods and tools are used. In general, the main challenge with regard to measuring soundscape is that soundscape is a multifaceted phenomenon and hence cannot be measured with a single number [5]. This leads to a wide range of applied data collection methods ranging from qualitative to quantitative research methods and combinations of them.

Interviews and questionnaires are the most commonly used tools in soundscape investigations [5]. These tools are usually applied in soundwalks, which is an empirical method for identifying a soundscape and components of a soundscape in various locations [6]. Soundwalks have been performed individually as well as in groups, but the group soundwalks appear to be more popular than individual soundwalks [7], see as an example figure 1. Soundwalks are differently performed varying in several aspects indicated in table 1.

Figure 1. Soundwalk in a urban park. Left person performs a binaural measurement by means of a binaural headset. The rest of the group listens to the acoustic envirnoment and has to fill out a questionnaire after the indicated listening period [8]

The potential explanatory power of soundwalk investigations was discussed by Fiebig and Herweg and they showed that assessments gained by repeated soundwalk measurements were more influenced by the respective sites than by the specific moment of time or test sample [9].

Table I. Methodic aspects of soundwalk

Aspects	*Options*
acoustic measurements	monaural-binaural, duration, measurement position (stationary, mobile)
sampling of participants and sample size	visitors vs. locals ad hoc sample, random sample, systematic sample number of participants
duration of soundwalk	snapshot vs. “long-term” measurement interval
instruction	level of attention directed towards sounds, emphasis on multi-modality, etc.
collection of visual information	pictures, videos

2.1 Interview

Different types of interviews are frequently applied to collect data about soundscapes, such as narrative interviews mainly working with open questions or guideline interviews using open and closed questions. In most cases, guided or narrative interviews try to explore associations, feelings, interpretations and emotions concerning the acoustic environment in depth. These explorations consider location-specific (e.g. identification and classification of sources at a certain area) as well as person-specific aspects (general preferences, noise sensitivity, personal coping and restoration strategies). As Kang et al. claim, qualitative and open interviewing currently undergoes a methodological change and is considered to provide valid data providing “a detailed picture of the soundscape as perceived by the people concerned” [10].

2.2 Questionnaire

Rating scales are often applied in soundscape investigations. According to Rohrmann rating scales are so popular because of their convenience - they are easy to explain and produce straightforward data [11]. The style of rating scales varies strongly in the soundscape investigations. For example, Nilsson et al. applied 5-point bipolar and unipolar category scales [12], Steele et al. used 7-pt. Likert scales [13] or Jeon et al. worked with 11-point numerical scales ranging from ‘not at all’ to ‘extremely’ [7] similar to the ISO/TS 15666 [14]. Table 2 provides examples illustrating the variety of rating scale types in soundscape investigations and research making it difficult to compare the results of studies.

Table II. Types of rating scales used in soundscape investigations and research

Scales properties	*Examples*
bipolar or unipolar	[15], [16]
discrete or analogue	[17], [18]
qualifiers (labels)	[13], [19]
judgment dimension(s) (attributes)	[20], [21]
number of categories	[8], [22]

In order to investigate the impact of different rating scales on the results, different scales were applied in consecutive soundwalks and their results compared. Rating scales (5-point unipolar continuous category scales) frequently applied in the COST Action TD 0804 [23] were compared to 5-point ordinal category-scales proposed in [15]. The scales use different qualifiers and attributes indicating the respective judgment dimensions. If necessary, the data was inversed to avoid negative correlations (in case of row 1 and 3 in table 3). The data collection is described in [9].

Table III. Comparison of results achieved by different rating scales

Comparison of scales	*Correlation coefficient*	*slope b_1 of linear regression*	*intercept n of linear regression*
unpleasantness (continuous) vs. pleasantness (discrete)	0.77**	0.83	≠ 0**
unpleasantness (continuous) vs. annoying (discrete)	0.65**	0,62	≠ 0**
loudness (continuous) vs. calm (discrete)	0.76**	0.98	≠ 0**

It can be seen in table 3 that the results of the different rating scales correlate statistically significant in all three cases. This means that similar data is gained by using the different scales. Moreover, both scale types exhibit similar standard deviations. However, as expected, since the correlation coefficient is clearly lower than 1 and there is an offset between the results, the rating scales do not produce fully congruent data. In case of the continuous rating scales the considered locations were judged as slightly more pleasant and less loud in average. This observation does not mean that one questionnaire is better than the other; it indicates that the investigator must be always aware of the fact that the choice of a certain rating scale with its qualifiers, number of categories, etc. has an impact on the result.

2.3 Observational methods

Observational methods are fundamentally different to methods mentioned above, since by applying observational methods the participants are usually not aware to be part of a study and might behave more naturally [24].
The majority of surveys use explicit measures, where test participants explicitly assess stimuli by self-report as an overt response with respect to criteria relevant for the object of investigation. Explicit measures give the test participants usually ample time to think about the evaluation and they exert control over it [25]. This means that only the overt response is explicitly measured and not the sensation, perception or emotion itself. Since we often respond differently when we know we are being watched than we don't know [26], researchers try to apply observational methods preventing biased and unnatural behavior. The general idea is that minimal interference with the test persons by the investigation leads to higher external validity. In general, since in participatory investigations the participants are in an attentive, analytic listening mode and mainly the noticeability and quality of the sounds are assessed [5], the experience and understanding of an acoustic environment might be biased limiting the validity of results. However, although non-participatory methods can help to overcome a number of biases which could significantly affect data collected about the perception of acoustic environments, there is a need to develop robust protocols for these kinds of behavioural observations to make non-participatory soundscape studies comparable for particular use cases [24].

3. Reliability

In general, it was observed that reliable data can be collected by means of in-situ acoustical and perceptual measurement even under uncontrolled conditions [27].

Figure 2 displays the change of variation of loudness measurement results in soundwalks in terms of the coefficient of variation, which is the standard deviation divided by the sample mean of a data set indicating the variation of measurement results independently of the unit. The similarity of loudness results according to the DIN 45631/A1 increase of 20 %, if the measurement time is extended from 1 to 3 minutes [27]. This result indicated the effect of measurement duration in uncontrolled settings on the (spread of) data.

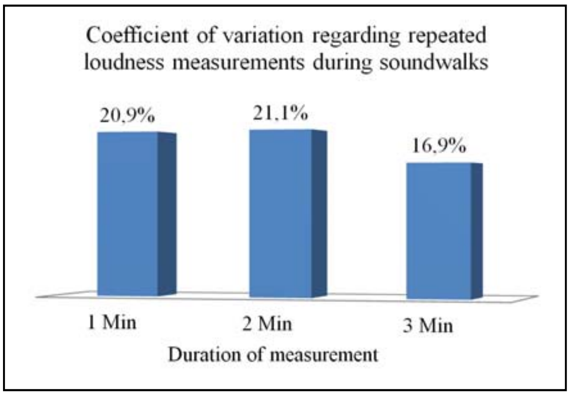

Figure 2. Coefficient of variation of loudness measurement results (DIN 45631/A1) of 13 repeated measurements in dependence of measurement duration

Moreover, it was observed that larger uncertainties in the assessment data were found for locations, which also show larger spread in the acoustical measurement results [27]. This observation illustrates that a thorough discussion of the reliability of (non-repeated) in-situ measurements is strictly mandatory. However, Fiebig and Herweg concluded referring to their soundwalk data collected over consecutive soundwalk measurements that although confounding variables like contextual features, weather, temperature, traffic situation cannot be controlled in-situ, the assessments of the different sites could be considered as reliable to a certain extent [9]. This means that the different sites in Aachen, Germany did provoke consistently similar responses over the years. Since the data was achieved by means of a between-subjects experiment design the influence of memory effects could be ruled out.

4. Conclusions

According to Aletta et al. it is necessary to agree on relevant soundscape descriptors in order to move the area of research forward requiring to agree on numerical scales and assessment procedures, as well as to standardize these [28]. Even if some methods and tools tend to recur more often than others, in most cases these are differently combined in surveys impeding the comparability of the results.

As shown by Fiebig [27] regarding reliability test quality of investigations using soundwalks, it is not possible to define general measurement requirements guaranteeing a high level of reliability, because certain locations require clearly longer measurements than other locations due to their stronger acoustical variability. However, a standard could strive for minimum measurement requirements leading to a (minimal) guaranteed level of reliability combined with requirements for preparatory examinations, repeated measurements and adequate documentation.

Moreover, it is reasonable to step up efforts to use biomonitoring techniques to investigate and assess responses to (acoustic) environments on a physiological level. According to Botteldooren et al. those techniques are more objectively than questionnaires, even when it comes to aesthetics or pleasure [5].

As indicated above, in the field of soundscape investigations, multiple methods and tools are applied to study and research the perception of acoustic environments for specific locations or in general. So far, although several methods are frequently applied a best practice seems not to be established.

In the near future, the ISO technical specification ISO/TS 12913-2 [29] will propose how to apply certain methods and tools and thus will probably stimulate a broader use of defined methods, which will allow for comparing results over diverse soundscape investigations. This should not prevent the development and application of new methods and tools for exploring further the way humans perceive their (acoustic) environments, since soundscape research still needs more scientific evidence of its potential to promote healthy urban environments through cognitive restoration [30]. But the technical specification related to soundscape data collection and reporting requirements might act as a kind of (preliminary) ‘ground truth’. Thus, having soundscape standards will make most likely a difference. It is desirable to establish best practice methods by means of standards leading to, on the one hand, comparable studies and on the other hand, to a broader use and acceptance in sectors usually relying mainly on standards having finally an impact on environmental noise assessment and urban planning.

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