Development of a new ISO Technical Specification on non-acoustic factors to improve the interpretation of socio-acoustic surveys

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ABSTRACT

There are currently four international standards relating directly to the human perception/evaluation of sound: ISO TS 15666 (assessment of noise annoyance) and ISO 12913 parts 1, 2 and 3 (measurement and assessment of soundscape quality). These standards aim to harmonise the characterisation of perceptions/reactions to a specific sound/sound environment. Personal, social and situational variables (often referred to as non-acoustic factors) are as important as acoustic features in determining human evaluation of sound. Currently, socio-acoustic surveys on annoyance and soundscapes attempt to quantify the influence of these non-acoustic factors using study-specific questions. This limits opportunities to merge different survey datasets in order to a) evaluate the effectiveness of specific questions as measuring instruments, b) improve the interpretation of survey data and c) identify effective non-acoustic interventions. This paper describes the initial stages in the development of a new ISO Technical Specification that aims to standardise the characterisation of non-acoustic factors in socio-acoustic surveys. A list of relevant non-acoustic factors is compiled and categorised based on relevance and the availability of standardised questions. Several different approaches for formulating an ISO Technical Specification are then discussed.

INTRODUCTION

Many countries already have regulations in place concerning the acceptability of environmental noise exposure, while others are likely to do so in the future. Such regulations often take into account relationships between noise exposure and noise-induced health outcomes, including long-term annoyance and sleep disturbance.

International standards have been developed for the measurement of certain characteristics of environmental sound. Two examples are ISO 1996 [1], which contains detailed specifications about basic quantities and procedures, measurement of sound, and guidance on the

application of these data to set noise limits; and ISO 20906:2009 [2], which specifies criteria for unattended monitoring of aircraft sound in the vicinity of airports.

Other standards focus on the effects of sound on humans. Long-term annoyance is an important health effect attributable to environmental noise, both as a health outcome in its own right, but also as a potential risk factor to other clinical health outcomes [3]. ISO/TS 15666 [4] provides a standardised specification for the assessment of noise annoyance by social and socio-acoustic surveys. This standard has enabled a more robust consolidation of the international evidence on noise annoyance, by ensuring consistency in the definition and measurement of this specific health endpoint [3].

It is generally accepted that annoyance reactions to environmental noise are determined partly by the acoustical characteristics of the stimulus, and partly by individual, situational and environmental factors (often referred to as non-acoustic factors) [5-8]. Non-acoustic factors are estimated to account for up to one third of the variance observed in annoyance reactions [5] and therefore offer significant opportunities in a) understanding the drivers of annoyance and b) opening up new possibilities for reducing the health burden attributable to noise annoyance. These opportunities are envisaged to be also applicable to self-reported sleep disturbance. In business terminology, non-acoustic factors have the potential to significantly increase the return on investment in noise effects investigation and mitigation. The WHO Environmental Noise Guidelines 2018 acknowledge the important contribution of non-acoustic factors, and recommend that:

> *"Future intervention studies should use validated and, where possible, harmonized measures of exposure and outcome, as well as of moderators and confounders. … Further, they should use measures of moderators and confounders, including repeated measurements of situational and personal variables such as activity interference, potential confounders such as noise sensitivity, coping strategies and a range of other attitudinal variables." [9]*

In recent years there has also been a growing interest in the soundscape approach (in line with the development of the ISO 12913 Soundscape standard series [10-12], with an emphasis on how sound in an environment is experienced by a person and/or people in context. According to ISO 12913-1:2014 assessing soundscape in context includes:

> *"the interrelationships between person and activity and place, in space and time… [and] context may influence soundscape through (1) the auditory sensation, (2) the interpretation of the auditory sensation, and (3) the responses to the acoustic environment." [10]*

Therefore identifying, measuring and assessing non-acoustic factors are central to measuring and assessing soundscape in accordance with the soundscape standards.

Despite the key role that non-acoustic factors play in both the "traditional" health protection (noise control) and health promotion/improvement (soundscape enhancement) approaches, to date, there is no standardised specification for the assessment of non-acoustic factors in social surveys. For example, the definition and standardisation of non-acoustic factors fall outside the scope of ISO/TS 15666. This means that the extent to which non-acoustic factors are investigated in a particular study is limited by the specialist expertise within the study group, and different studies tend to develop project-specific survey instruments. A standardised approach to non-acoustic factors can offer significant benefits in:

a) improving the quality, reliability and consistency of the survey instruments; and

b) enabling data that can be consolidated across projects, thereby strengthening the evidence base and ultimately leading to a better understanding and application of non-acoustic factors to improve the health and quality of life of citizens across the globe.

On behalf of the British Standards Institute (BSI), the authors of this paper have been tasked with drafting an outline scope for a new International Technical Specification (ISO/TS) on non-acoustic factors. This paper describes the progress to date. The content of this paper includes valuable contributions received from a panel of external experts that was informally consulted in 2020 – see Acknowledgements.

PROPOSED AIM AND SCOPE

Definition of non-acoustic factors

There does not appear to be a single consensus definition of the term 'non-acoustic factors' in the literature. The first aim of the ISO/TS, therefore, would be to set out a standard definition for the term that can be widely agreed upon. Some examples of definitions or descriptions of non-acoustic factors in the literature include the following:

a) "all those factors other than noise level alone which contribute to noise annoyance and similar effects" [7]
b) "moderating variables, i.e. personal and social aspects of the residents" [5]
c) "differences in auditory processing of those cues (e.g. spectral-shape sensitivity)" [13]
d) "by convention: all non-DNL factors" (DNL= day-night average sound level in dB) [6]
e) "all those factors other than noise level which contribute to annoyance" [14].

Therefore, at present, there is a wide range of interpretation of the term, ranging from everything apart from the long-term average noise level [d]; to only 'moderating variables' i.e. personal and social aspects of the residents [b]. The following extract, from a document published by a campaign group from the UK, highlights some of the complexities that can arise as a result of this ambiguity:

> *"In literature the level of background noise, the so-called ambient noise, is considered both an acoustic factor and a non-acoustic factor. This implicates that authors disagree in which category ambient noise belongs. Kroesen (2006) clearly identifies background noise as an acoustic factor. Background noise is after all a sound. On the other hand, Sanchez et al . (2015), classified ambient noise as a non-acoustic factor. They divide non-acoustic factors into personal, social and situational factors. The latter refers to characteristics in which the noise event takes place. Background noise is therefore not the sound event itself, but a non-acoustic situational factor."* [15]

Therefore, a key aim for the new TS is to achieve consensus on a clear definition for the term "non-acoustic factors".

From initial conversations with a small number of experts there was agreement that physical acoustic quantities should not be considered as non-acoustic factors. Therefore averaged sound level (L_{eq}-based metrics, L_{den}, L_{dn}, L_{night}), maximum/peak sound level, number-of-events exceeding a set threshold (N_{xx}), amplitude modulation (for wind turbine noise), outdoor to indoor sound attenuation and background sound level should be considered as "acoustic

factors". There are other objective quantities that are strongly related to acoustic parameter, such as number of vehicle pass-bys / flyovers, height of the noise source (with respect to aircraft flyovers), and duration of respite (predictable periods of relief from noise from a specific source) that are likely to lead to some debate as to whether they can be categorized as acoustic or non-acoustic. It is also recognised that some factors can have both acoustic and non-acoustic components; e.g. background/ambient sound can be described both in terms of acoustic quantities (such as the L_{90} percentile), and with semantic descriptors such as 'eventful/uneventful' or "tranquil/chaotic".

A tentative definition for non-acoustic factors may be:

> *"All factors other than the objective, measured or modelled acoustic parameters which influence the process of perceiving, experiencing and/or understanding an acoustic environment in context, without being part of the causal chain of this process."*

We anticipate a healthy debate and further refinement of this proposed definition, particularly on the last phrase, for example on whether certain non-acoustic factors can function both as moderator and mediator variables [16].

Scope of the Technical Specification

It is proposed to publish this standard as a ISO/TS because, according to the International Standards Organisation, a TS:

> *"addresses work still under technical development, or where it is believed that there will be a future, but not immediate, possibility of agreement on an International Standard…[While] a TS can be published for immediate use… it also provides a means to obtain feedback."* [17]

The feedback period is important because the review period for a ISO/TS is shorter than that of a full standard (i.e. three years for a TS versus five years for an International Standard) [18]. ISO recommends that a Technical Specification has a maximum life of six years, after which it would, ideally, progress to be transformed to an International Standard. While this is not a strict rule, it is a good indicator of the use and development of the specific area under review. As research regarding non-acoustic factors is rapidly evolving, the relative flexibility of a TS is apposite.

This TS would sit at the interface of the traditional noise control and soundscape approaches and can be seen as complimentary to ISO/TS15666 and the ISO 12913 series. We recommend that this TS should have a specific focus on those non-acoustic factors that will help understand the effects of noise and soundscape assessment in relation to health and quality of life. Therefore, the scope of this TS would cover the collection, analysis and interpretation of non-acoustic factors in all environments, both indoor and outdoor, in any context. This could include:

- Socio-acoustic surveys investigating noise annoyance and self-reported sleep disturbance at home. "Home" includes both the indoor space and any external amenity space that forms part of the dwelling (such as balconies, gardens and any shared private amenity space).
- Soundscape assessments of general living and recreational environments, including indoor and outdoor urban, suburban, peri-urban and rural areas.
- Work settings.

It is envisaged that procedural aspects that are required to ensure high-quality social surveys, which are not specific to social surveys on noise (such as sampling methods), would fall outside the scope of this Technical Specification. Age, gender, education, socio-economic status are considered to be important non-acoustic factors. However, questions on these attributes tend to follow national and/or sector-specific methodologies (whether in government, academia, industry or practice), and therefore are expected to fall outside the scope of the TS, albeit they are important and necessary data to collect.

There are additional specific details on the scope that need to be discussed and agreed early on in the development of the Technical Specification. For example, whether it would be applicable to surveys of all ages, or only for adult groups, and if it would be relevant to all sources of sound, as is inherent to a soundscape approach (e.g. transport, wind turbines, industry, construction, building services equipment, neighbours, nature, etc.).

An International Standard/TS may include both normative and informative references/content. For this TS the normative content could include:

- a list of non-acoustic factors that should be included as a minimum in socio-acoustic surveys;
- if consensus can be achieved, exact wording / survey instruments to measure specific non-acoustic factors;
- if consensus can be achieved, methods for data analysis and interpretation.

Informative content could include:

- additional non-acoustic factors that may be included, depending on survey/study objective;
- examples of wording to measure non-acoustic factors (when consensus cannot be reached on a single method);
- examples of methods for data analysis and interpretation.

This TS, and the data it helps generate is expected to provide significant added value to acousticians, planners, designers, researchers, psychologists, sociologists, epidemiologists, environmental and public health practitioners interested in:

- the appraisal of a sound environment in context;
- soundscape appraisal when applying the ISO soundscape standard series;
- moderators of sound impacts – health pathway;
- policy development;
- improving the accuracy of environmental noise and health impact assessments; and
- designing interventions to enhance the soundscape and improve health outcomes.

PROPOSED STRUCTURE

Due to the complexity of the subject area, and the likely need to engage different experts across multiple disciplines at different stages, the proposed standard can be broken down into several parts. Our preferred approach would be for the ISO/TS to follow the ISO 12913 Soundscape standard series structure, i.e. divided into the following parts:

- Part 1 - Definition and conceptual framework;

- Part 2 - Data collection and reporting (including standardised questions);
- Part 3 - Data analysis;
- Part 4 - Interpretation.

Part 1 would set out an overarching definition of non-acoustic factors (as discussed in the previous section), a conceptual framework and a categorisation framework.

Conceptual framework and categorisation

Defining a conceptual framework in Part I of the TS would help contextualising future discussions. The following figure is a slightly amended version of Figure 1 in ISO 12913-1, and can form a starting point for discussion.

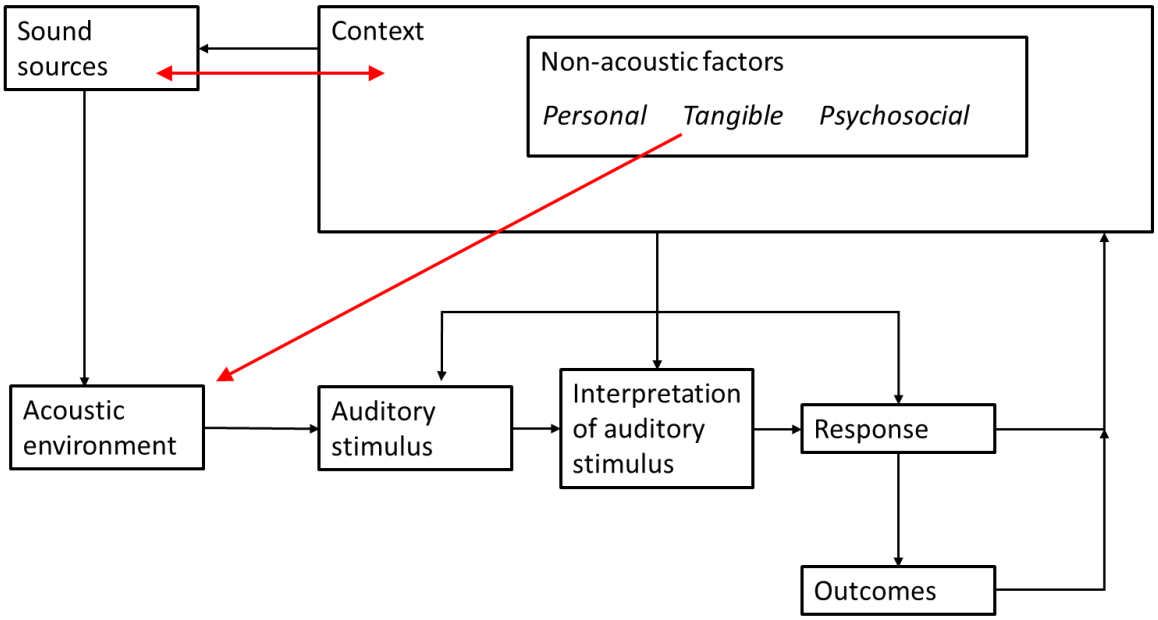

Figure 1: Influence of non-acoustic factors on the interpretation of auditory stimulus – a conceptual diagram

There is a considerable amount of literature relating to non-acoustic factors (see for example [5,8,19-27]), although, as discussed previously, it is not always cohesive. Drawing on this literature it is possible to tentatively define a number of broad categories of non-acoustic factors. For example, Guski [5] distinguishes between four categories: individual (or personal), social, situational and environmental. Riedel [26] has proposed three categories: personal, tangible and psychosocial. It is worth noting that there may be overlap between such categories, for example between individual and social factors. An agreed set of broad categories of non-acoustic factors will be an important feature of Part I of the proposed TS, along with a non-exhaustive list of examples for each.

As an example, following Riedel's categories, the following factors may be included:

Table 1: Example categories of non-acoustic factors

Category of non-acoustic factor	**Illustrative Examples**
Personal: *strongly linked to an individual, show stability over time and situation, vary between individuals.*	Noise sensitivity; Coping capacity; Perceived control; Perceived fear.
Tangible: *properties of the specific environment.*	Access to green space; Quiet façade; Location of inhabited space(s); Visual modifiers.
Psychosocial: *shared between individuals of a community.*	Perceived fairness; Perceived community benefit/disbenefit; Attitude towards noise authorities.

CONCLUSION

A new multi-part ISO Technical Standard is proposed to formalise the assessment of non-acoustic factors relevant to the effects of noise and soundscape assessment in relation to health and quality of life. Such a standard, and the data it would help generate, are expected to offer significant added value to acousticians, planners, designers, researchers, psychologists, sociologists, epidemiologists and environmental and public health practitioners interested in the relationships between sound and health and quality of life. The development of the TS is at the initial stages, and this paper provides an overview of potential scope, definitions and conceptual framework. The development of an international standard is a collaborative activity, and interested people are encouraged to engage in this process via their respective national standardization bodies.

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