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# Development of a conceptual framework for a new international standard on non-acoustic factors

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**ABSTRACT**

*The human response to a sound environment is influenced by factors that interlink the person, activity, and place. These factors are often referenced as discrete elements of the "context" in soundscapes, and as "non-acoustic factors" within the noise and health community. Despite their importance, researchers and practitioners tend to use different terminology and methods for investigating them, which complicates evidence synthesis and recommendations for designing healthier sound environments. Since 2022, Working Group 68 within ISO TC 43/SC 1 has been developing a new Technical Specification to standardise the definition and use of such non-acoustic factors. Part 1, due for publication in 2025, will include a definition and a conceptual framework. As part of this work, we conducted a rapid scoping literature search to assist in the development of the conceptual framework. Fourteen articles were shortlisted, which were used to draft a framework that reflects the definition of non-acoustic factors, including its main categories (personal, psychosocial, tangible/environmental, and situational) and the moderating and mediating role of non-acoustic factors on the human perceptual and affective response (emotional and behavioural) and associated health outcomes.*

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## 1. INTRODUCTION

"Non-acoustic factors" is a broad term used within the noise and health community to describe factors separate to the acoustic features of a sound environment that can influence how people respond to a sound environment. Often these factors interlink the person, activity, and place within a sound environment, commonly referred to as "context" within the soundscape literature [1, 2]. Multivariate regression analyses of socio-acoustic surveys suggest that known non-acoustic factors can account for approximately one third of the variance observed in noise annoyance reactions [3-7]. These results have been further replicated in soundscape studies, with multi-level regression analysis indicating that non-acoustic factors can explain 35% of the variance in pleasantness perception (i.e. the opposite dimension to annoyance) and 18% of the variance in eventfulness perception [8]. Consideration of non-acoustic factors in policy and practice could also lead to more equitable health outcomes [9]. Yet, as described elsewhere, for example, [10] researchers and practitioners tend to use different terminology and methods for investigating these factors, making evidence synthesis and designing interventions to mitigate the health impacts from noise a challenge. Since 2022, Working Group 68 within the International Organization for Standardization Technical Committee 43 (Acoustics), Sub-committee 1 (Noise) (ISO TC 43/SC 1) has been developing a new Technical Specification (TS) to standardise the definition and use of non-acoustic factors [11]. Further details on the proposed ISO TS aims, scope and structure can be found in [10]. This paper documents work carried out to date to develop a conceptual framework for Part 1 of the TS: Definition and conceptual framework.

## 2. NON-ACOUSTIC FACTORS - THEORETICAL BACKGROUND

As described in [10], the development of a definition and conceptual framework for non-acoustic factors drew on two key disciplines. The first area considered the role of non-acoustic factors within the relationship between noise exposure and noise-induced health outcomes. Most of the literature in this area was on the relationship between transportation noise and noise annoyance [3, 7, 12-15]. The second area considered non-acoustic factors in relation to the literature on soundscapes, particularly with reference to the "context" as defined in the ISO 12913 Soundscape series [2, 16-31]. This initial work informed discussion within ISO TC 43/SC 1/WG 68 and ICBEN Team 6 to develop a (provisional) definition for non-acoustic factors: *Specific factors, other than the objective, measured or modelled acoustic parameters, which influence the process of perceiving, experiencing, understanding and/or reacting to an acoustic environment.*

Such factors can be grouped into four categories (examples are included for illustrative purposes, and are not intended to represent an exhaustive list; some non-acoustic factors could also intersect two or more categories):

- **Personal** – strongly linked to an individual, show stability over time and situation, and vary between individuals (e.g., noise sensitivity, coping capacity, perceived control, and perceived fear) [3].
- **Psychosocial** – shared between individuals of a community (e.g., perceived fairness, perceived community, (dis)benefits, cultural and religious beliefs) [3].
- **Tangible/environmental** – stable attributes of the immediate and/or local environment (e.g., access to green space, quiet façade, location, and orientation of inhabited space(s) in relation to sound source and visual modifiers) [32, 33].
- **Situational** – factors linked to the activity and/or place and/or time of experiencing the sound (e.g., the time of day, working or a recreational activity, alone or with a companion)[13].

## 3. NON-ACOUSTIC FACTORS - CONCEPTUAL FRAMEWORK

### 3.1. Aims

The aim of the conceptual framework is to help users of the standard understand where and how non-acoustic factors sit in relation to noise and health and soundscapes assessments. This is consistent with the vision that the non-acoustic factors TS is seen to be complimentary to other relevant standards and frameworks, such as the ISO/TS 15666 Assessment of Noise Annoyance by Means of Social and Socio-acoustic Surveys [34], ISO 12913 Soundscape series [2, 29, 30] and ISO 1996 Description, Measurement and Assessment of Environmental Noise series [35, 36].

### 3.2. Method

There were several stages involved in the development of the conceptual framework. The model needed to capture: the moderating and mediating role of non-acoustic factors on human response (emotional and behavioural) and health outcomes [10]; the link between non-acoustic factors and the "context" as defined in ISO 12913 series [2, 29, 30]; and to reflect the distinct nature of soundscapes, evaluation, and affective response.

A scoping review was conducted in June 2022 to gain a better understanding of the concepts described above and other conceptual frameworks within the topic area. In brief, Google Scholar, and an internal database of over 40 different databases, including Medline and Scopus were searched using a combination of terms relevant to our aims, such as soundscape, non-acoustic factors, noise, annoyance, bother, disturb and cognitive-motivational determinants AND framework. The search yielded 471 articles that were screened for frameworks that were deemed as potentially useful (visually and topically), resulting in 14 articles being screened on full text [16, 37-49], which included articles that were known to the authors before the search. The frameworks were grouped into categories of similar designs (e.g., cycles, wheels, and tiers) and topic themes were identified: source of sound, acoustic environment, interpretation/appraisal, physiological response, emotional response, behavioural response, coping strategies, health outcomes and temporal domain (such as, the here and now, compared to past experiences, and to future expectations). In essence, the themes that were identified in the scoping review aligned with the broader components identified in an earlier stage (soundscape, evaluation, and affective response).

Based on the model requirements and findings from the literature search, the authors of this paper held an in-person workshop to develop initial proposals for a conceptual framework. During the workshop there was consensus that the conceptual framework should:

a) be person-centred, i.e., take an individual rather than community level approach;

b) have a small number of separate concepts; and

c) give prominence to the four non-acoustic factor categories (personal, psychosocial, tangible/environmental, and situational).

It was also recognised that the model should be as simple as possible, in monochrome and using minimal arrows and other similar design features.

### 3.3 Conceptual framework

Following the non-acoustic factors definition (section 2) and the guidelines described in section 3.2, Figure 1 presents an initial proposal for the conceptual framework.

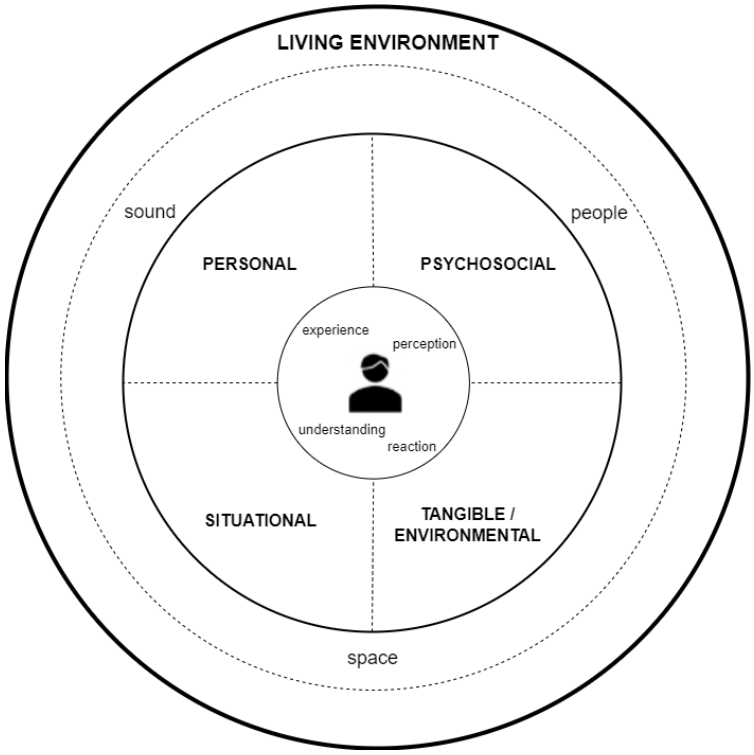


Figure 1: Initial proposal for the non-acoustic factors conceptual framework, which will be further developed through stakeholder engagement.

The design focuses on three elements of the non-acoustic factors definition: (1) the specific factors, (2) (which influence) the process of perceiving, experiencing, understanding and/or reacting, (3) (to an) acoustic environment. These concepts have been captured in three respective circles to reflect that all the elements interlink and to display a non-hierarchical, although multi-level design. The conceptual framework starts with the outer circle (living environment) and moves inwards to the centre circle (the icon representing the individual). We have placed the individual at the centre to reflect the person-centred nature of non-acoustic factors. Along those lines, we have not included "affective response" as a specific feature. Instead, the centre circle encompasses both the evaluation and affective response; the process of experiencing, perceiving, understanding, and/or reacting to the acoustic environment; and any resulting outcomes. In addition, broken lines are used between the four non-acoustic factor categories to reflect the possible interactions or interrelationships between the different categories, which will be explored in future parts of the standard series. It is recognised that some non-acoustic factors may sit closer to the individual or to the environment, and future revisions of the framework may better reflect this. The circle that includes people, sound, and space aims to show a link between the conceptual framework and the ISO 12913 Soundscape series [2, 29, 30]. "Space" is used here instead of "place" as the acoustic environment can be "actual or stimulated" and "as experienced or in memory" [2].

## 4. DISCUSSION AND CONCLUSION

Non-acoustic factors are crucial elements of noise and health and soundscape studies. These factors can be categorised as personal, situational, tangible/environmental, and situational. Working Group 68 within the International Organization for Standardization Technical Committee 43 (Acoustics), Sub-committee 1 (Noise) (ISO TC 43/SC 1) has been developing a new Technical Specification (TS) to standardize the definition and use of non-acoustic factors. This paper describes the initial stages of developing a conceptual framework to help users of

the standard understand where and how non-acoustic factors sit in relation to noise and health and soundscape assessments.

Standardising a complex multi-disciplinary topic is a particularly challenging endeavour in terms of engaging and getting meaningful contributions from the many different stakeholders, and also achieving consensus through compromise [50, 51]. However, we believe that the benefits of standardisation outweigh these challenges, as proven by the standardisation on noise annoyance [34] and soundscapes [2, 29, 30]. This brief paper, and the poster session at the Inter-noise 2024 conference offer an opportunity for raising awareness of this work. The authors would welcome all feedback from relevant stakeholders on the proposals in this paper and the broader work on standardising non-acoustic factors.

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