



Revising ISO/TS 15666 – the noise annoyance standard

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ABSTRACT

Noise annoyance is the most prevalent community response in populations exposed to environmental noise. In 1993 the ICBEN Community Response to Noise team started work formalising a standardised methodology for assessing noise annoyance, which resulted in reporting guidelines and recommendations for standard questions, which was later published by the International Standards Organization as a Technical Standard in 2003 (ISO/TS 15666:2003). This Technical Standard is used to quantify exposure-response relationships between noise exposure and annoyance internationally. ISO/TS 15666:2003 has now been in operation for nearly two decades. This paper will report on the work of an international working group, as part of ISO TC43/SC1/WG62, tasked with revising and updating the Technical Standard. This paper will review use of the Technical Standard; discuss its revision; and highlight research needs and gaps that, if addressed, would help to further strengthen the methodology underlying the assessment of noise annoyance.

INTRODUCTION

Noise annoyance is a key health outcome used to assess community response to environmental noise exposure such as aircraft noise, road traffic noise or railway noise. The assessment of noise annoyance in the home environment is governed by an International Standard ISO/TS 15666:2003 '*Acoustics — Assessment of noise annoyance by means of social and socio-acoustic surveys*' [1].

Development of the specification was started in 1993 by the 'ICBEN Community Response to Noise' team who undertook seven years of psychometric research to formalise a standardised methodology for assessing noise annoyance, which set out the questions to be asked, the response scales, and key aspects of conducting and reporting the survey [2, 3].

The ICBEN team developed a noise reaction measure for social surveys that had several characteristics: it enabled a valid international comparison of survey results within and between languages; provided a high quality and reliable measure of a general reaction to noise experienced in a residential environment; gave transparent results that could be consistently interpreted by survey respondents and policy makers; was suitable for all questionnaire administration modes at that time including face-to-face, telephone, and self-completion; and was likely to be adopted internationally [3].

The resulting noise reaction 5-point verbal question and 11-point numeric question have been used to quantify exposure-response curves between noise exposure and annoyance for a variety of environmental noise exposures covering individual studies of aircraft, road traffic noise, railway noise, wind turbine noise exposure [4, 5, 6, 7, 8, 9, 10, 11], inter alia, as well as in the synthesis of findings across studies [12, 13] that are frequently relied on by governments and policy makers to quantify noise impacts and their health effects [14], and to inform mitigation strategies.

Different strategies may be used to transform the survey results into exposure-response curves as explained in the International Standard ISO 1996-1:2016 [15]. This standard has informative annexes for estimating prevalence of a population highly annoyed as a function of adjusted day-night or day-evening-night sound level using the Community Tolerance Level method (CTL) or a polynomial regression method.

ISO/TS 15666:2003 has now been in operation for nearly 20 years. This paper reviews use of the standard to date, the technical revision of the International Standard, and highlights research needs and gaps that, if addressed in the next few years, would help to further strengthen the methodology underlying the assessment of noise annoyance.

The discussion presented in this paper has been undertaken by an international team convened by the United Kingdom, as a work item within ISO TC43/SC1/WG62 entitled "Revision of ISO/TS 15666 – Assessment of noise annoyance by means of social and socio-acoustic surveys". The team was tasked with revising the Standard between 2017-2021. The updated ISO/TS 15666:2021 will be published in early summer 2021 [16].

REVISION OF THE TECHNICAL SPECIFICATION: ISO/TS 15666:2021

This section describes some of the key changes to the revised Standard. A review of published papers and reports using ISO/TS 15666:2003 suggest that some common adaptations have occurred in use that may not meet the spirit of the original standard. Common adaptations include applying the standard to settings outside the home (e.g., offices, public spaces); adding a 'do not hear' question prior to the question to exclude respondents

from answering the questions; administering only one of the questions; changing the wording or presentation; and not providing the checklist of reporting requirements that forms part of the Standard.

Two measures of annoyance

The ICBEN team proposed that two noise reaction questions (the 5-point verbal question and the 11-point numeric question) should be used in a survey as this was psychometrically robust; offered greater reliability of assessment; and enabled comparison between studies. It also facilitates the calculation of the percentage 'highly annoyed' (%HA), the endpoint that is of most interest internationally. Whilst this requirement was set out in ISO/TS 15666:2003 many surveys use only one of the questions, due to space, cost and time constraints of conducting the survey; a historic preference for one of the questions over the other; or the fear that it may be perceived as repetitive to ask both questions.

ISO/TS 15666:2021 relaxes the requirement that both questions should be asked, acknowledging that it may not always be possible or practical to include both questions. The updated specification now includes discussion of the advantages and disadvantages of each question to help users balance the strengths and weaknesses of each question against their own research objectives. If having to choose between the verbal and/or the numeric question, ISO/TS 15666:2021 recommends using the 11-point numeric question, as it offers the greatest options for statistical testing and cross-study comparisons.

Scope of the questions

The language of the noise reaction question designed by the ICBEN team, "*Thinking about the last 12 months, when you are here at home, to what extent are you personally bothered, annoyed or disturbed by noise from road traffic noise?*" contains within it some inherent assumptions such as annoyance being rated for the past year and for the home environment in its entirety covering internal and external areas. A review of studies conducted over the past two decades identified that a number of adaptations have been made to the question in its use to assess how annoyance might vary for different times of the day (e.g., day, evening, night-time) and for different places within the home environment (inside; outside; in the garden; in different rooms within the home). ISO/TS 15666:2021 clarifies the assumption that the question is designed to address annoyance over the whole 24-hour period during the last 12 months or so, i.e., annoyance integrated over the daytime, evening and night-time periods in locations in and around the home including external areas such as the garden or balcony. Whilst the revision reinforces the scope of the question it also now includes guidance on the use of subsequent questions to examine different contexts and times of day, highlighting the importance of stating the precise hours being considered if interested in different times of the day.

The revised standard also emphasises the need to align the annoyance reference period with the noise metric being evaluated. Historically, the reference period was '12-months or so', based on the notion that sustained (and not transient) annoyance is more relevant to health [17]. Nevertheless, there may be situations where evaluating short-term annoyance may be more appropriate, for example in relation to a recent change in exposure, in which case the question can assess annoyance over this time-period to the extent that the noise is also evaluated over the same time-period.

Scoring ‘Highly Annoyed’

Since the original Schultz curves [18] it has been the norm to plot the percentage of the population ‘highly annoyed’ by noise exposure to obtain an annoyance exposure-response function. However, use and quantification of ‘highly annoyed’ is not standardised. ISO/TS 15666:2003 did not prescribe how the 5-point verbal question and the 11-point numeric question should be scored, allowing for flexibility in how countries may wish to score annoyance. Nevertheless, over-time it has become apparent that the lack of standardised scoring can impede cross-study and cross-country comparisons.

Schultz defined ‘highly annoyed’ as the top 28% of the 11-point numeric question [18]. As specified in the extensive IC BEN Team 6 analysis [3] and consistent with Schultz’s analysis [18] “highly annoyed” can be defined on the 5-point verbal question as the top two verbal response categories (i.e., very and extremely). At face value, it would appear that this gives the two questions different cut-offs to define ‘highly annoyed’, as the cut off is based on the top 28% for the numeric question and on the top 40% (the top two responses on the 5-point Likert scale (2/5)) for the verbal question. However, comparing the two questions like this is not really appropriate as verbal scales and numeric scales are interpreted differently by respondents. Further, the 40% description for the cut-off for the 5-point verbal question is only used to illustrate the issue of cut-offs for ‘highly annoyed’. It does not imply that the 5-point verbal question should be treated numerically. Our review of use of ISO/TS 15666:2003 has identified that several studies provided numeric values to the verbal response categories, e.g., 1-5 or 1-50, which is not consistent with the TS.

A common adaptation in the past decade based on analyses of large-scale studies [19, 20, 21] have suggested that comparisons between the numeric and verbal questions can be improved by a weighting scheme, whereby: “highly annoyed” is defined as the top two verbal response categories on the 5-point verbal question (i.e., very and extremely) with ‘extremely’ counted in full, and ‘very’ weighted by a factor 0.4, which creates a greater mathematical similarity between the 5-point verbal and 11-point numeric questions.

The review of studies found that it is not always clearly reported how ‘highly annoyed’ has been scored. The revised specification sets out to standardise the scoring and reporting nomenclature for ‘highly annoyed’ to aid cross-study comparison and harmonisation. The following scoring and naming for the method is advised:

- numerical values 8, 9, and 10 for the 11-point numeric question – to be referred to as ‘HA_N’;
- the top two verbal response categories for the 5-point verbal question (i.e., very and extremely) – to be referred to as ‘HA_V’;
- the top two verbal response categories for the 5-point verbal question, weighted with ‘extremely’ counted in full, and ‘very’ weighted by a factor 0.4 – to be referred to as ‘HA_{VW}’.

These specifications do not prevent users and countries adopting other forms of scoring as preferred or needed for historic reasons. However, in such situations, the revised specification encourages the additional presentation of the survey data in terms of HA_N, HA_V and HA_{VW} so that the data could later be included in meta-analyses and/or compared to other study findings.

Standardisation

At the outset of designing a survey, researchers should familiarise themselves with the detail within the Standard and the supporting documentation. It is clear that many researchers, with the best of intentions, are using the noise reaction questions to assess annoyance but are not following the details of the specification. We encourage researchers planning to undertake an annoyance survey to take time to understand the philosophy and detail that lies behind the specification [2, 3], which set out how the survey was designed and should be conducted. Details are also provided in the Annexes to the International Standard.

We have noted that many studies are not presenting the response options for the 5-point verbal question vertically, as specified in the Technical Standard. The vertical presentation, as opposed to horizontal presentation, is intended to ensure the response options are equally spaced.

It has also been noted that the order of presentation for the response options for the 5-point verbal question has changed, being ordered from “Extremely” to “Not at all” for the IC BEN recommendations [2, 3] and from “Not at all” to “Extremely” in ISO/TS 15666:2003. This has led to two versions of the 5-point verbal question being in use. It is unclear why the order was changed in ISO/TS 15666:2003. It is possible that a low to high order of presentation might seem like a more natural way of presenting these options, particularly for some languages and cultures. There are concerns that starting with ‘Extremely’ could bias responses towards ‘higher annoyance’ but the same argument can be made for starting with ‘Not at all’ which could bias towards ‘lower annoyance’. Lacking evidence from studies that compare responses using the two approaches, ISO/TS 15666:2021 clarifies that the order should be ‘Not at all’ to “Extremely” to maintain consistency with ISO/TS 15666:2003 and to standardise the approach going forward. This approach is also consistent with the presentation of the 11-point numeric question which ranges from low to high (0 to 10).

ISO/TS 15666:2003 contained a checklist about information that should be reported for a survey, which has been updated in ISO/TS 15666:2021. The majority of surveys that are published do not provide all or most of the detail requested on the checklist. It is important to consult the checklist at the design stage of the survey, as well as to report this detail when publishing. Providing this detail enables users of the survey to evaluate the robustness of the study and is also essential for subsequent meta-analyses attempting to pool study findings, as it enables methodological differences and similarities between surveys to be identified. We take this opportunity not only to draw researchers’ attention to the checklist, but also encourage those peer-reviewing or editing journal papers to make sure the checklist is reported in an Appendix or Supplementary Material. The overall standard of annoyance reporting will improve if this requirement is embraced.

RESEARCH NEEDS

It is beyond the scope of this paper to report the findings of the evidence reviews in detail. However, it is clear that further studies examining several methodological aspects of the standardisation are needed to feed into the next revision of the specification. Studies should seek to explore methodological variations in the noise reaction questions, after implementation of the Standard questions.

Key areas for research include:

- the assumption that participants are rating their noise annoyance over the past 12 months. It is not known how respondents integrate or recall their experience over the

past 12 months. It seems plausible that people may be recalling the past month or so and basing their 12-month evaluation on their more recent experience. This could result in weaker associations between annoyance and a long-term noise metrics (e.g., DENL).

- the assumption that participants are rating their noise annoyance for the home as a holistic environment, i.e., covering internal and external areas. It is not known how participants integrate assessments for different areas of the home or how they might combine to reflect the assessment in the overall noise reaction questions. Are respondents reporting annoyance for the 'worst' area in their home or are they integrating the reaction across different areas?
- the assumption that participants are rating their noise annoyance for the home over a 24-hour period. Further studies comparing data on annoyance for different times of the day to the standard noise reaction questions would be helpful.

Digital technology could be used to collect noise reaction responses more frequently from participants to shed light on these issues. There is also research to be undertaken to understand how electronic methods of presenting the standard compare to the traditional data collection methods.

Recent surveys have highlighted how the exposure-response curve for annoyance is shifted considerably in relation to non-acoustic factors such as attitudes, demographic factors, and environmental and contextual factors [5, 12, 22] and it has been hypothesised that these factors account for between-study variation in exposure-response curves. There is an appetite within the annoyance field to develop a standardised assessment survey addressing non-acoustic factors to aid further harmonisation across surveys and this is currently being undertaken as part of a separate work item, led by the UK, within ISO TC43/SC1/WG62 by a different ISO Working Group. While it is, therefore, beyond the remit of the current project to examine non-acoustic factors, per se, a brief overview of the work item on non-acoustic factors, as is described by Fenech, Lavia, Rodgers & Notley et al., (2021), is summarised below and will also be presented at IC BEN 2021.

'There are currently four International Standards relating directly to the human perception/evaluation of sound: ISO TS/15666 - Assessment of noise annoyance by means of social and socio-acoustic surveys [1] and ISO 12913 parts 1, 2 and 3 (regarding the measurement and assessment of soundscape quality) [23, 24, 25]. 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. The aim of the working group is to develop an ISO Technical Specification to standardise the characterisation of non-acoustic factors in socio-acoustic surveys. A paper discussing the initial findings of the working group and the exploration of different approaches for formulating the proposed TS has been developed for discussion at IC BEN 2021 [26].'

CONCLUSION

Noise annoyance is a key health outcome for communities, stakeholders and policy makers dealing with environmental noise exposure. The previous methodologically robust work of the ICBEN team, several decades ago, standardising the methodology has placed annoyance at the forefront of discussions about the public health effects of environmental noise. This paper highlights the key revisions in ISO/TS15666:2021, all of which aim to encourage greater compliance and standardisation of the specification to aid comparison and pooling of survey data for use by environmental policy makers and communities.

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