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Development of a social survey for the study of vibration annoyance in residential environments: Good practice guidance

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ABSTRACT

This paper outlines good practice guidelines for developing a social survey to investigate public annoyance in relation to environmental vibration. Drawing on the development of international good practice guidelines and research into noise and vibration annoyance, a number of challenges that arise in developing such a survey are addressed. The issues include the development of rating scales for annoyance and social factors, decisions regarding the terminology used in the survey to define annoyance, different sources of vibration, and how respondents' consider the residential area of investigation when completing the survey. The process highlights the need to combine disciplines, in this case applying knowledge from social sciences and acoustics in order to ensure the collection of robust and reliable data. The final survey developed from this process was used in a national survey in the United Kingdom which aimed to produce exposure–response relationships for vibration and annoyance in relation to railway activity, construction activity, and internal vibration sources.

1. Vibration in a multi-disciplinary context

In order to develop an accurate tool for the measurement of annoyance in relation to vibration, it is important to consider vibration in a multi-disciplinary context due to its impact on areas as broad as urban development, health, well-being and quality of life.

A growing number of areas are becoming more urbanised, with large concentrations of people living in close geographical proximity to one another, with increasing construction work being undertaken and transportation networks developed in order to cope with and provide for population growth and dispersion. Despite the apparent advantages of high density living, it has been argued that many cities and towns are still *"far removed from the safe, clean and liveable environments they theoretically could be"* [1]. The development of infrastructure, alongside the mechanisation and urbanisation of contemporary life, can often result in exposure to vibration and noise from a range of sources such as road, rail, construction, industrial and commercial activities, road works, aircraft, neighbours, as well as from new sources such as microgeneration (e.g. domestic wind turbines). The Health Protection Agency recently reported that approximately 30% of the UK population express dissatisfaction with noise in their environment [2] and the World Health Organization have identified noise exposure at home as one of their environmental health inequality indicators [3].

Environmental conditions or ambient stressors, can impact upon and/or cause disturbances on residential populations [4]. Such environmental stressors, for instance when subsequently resulting in sleep disturbance, can also result in increased levels of stress and therefore possibly increasing blood pressure levels and rates of cardiovascular disease [3]. This link has also been identified by the United Kingdom's Department of Environment, Food and Rural Affairs [5] and earlier by the European Commission Working Group on Health and Socio-Economic Aspects [6]. A number of these environmental conditions have been investigated in terms of their impact on the individual, including noise [7,8], visual or physical environments/landscapes [9–11], odour [12,13], vibration [14–18] and crowding [19].

Like many environmental variables, vibration is particularly significant to the urban context due to the concentrations of people residing near major transport links (road and rail), in close proximity to construction and industrial activity, and also to one another. The increasing amount of mixed use developments/work-live units and changes in the way we generate electricity are also resulting in

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new sources of vibration and noise in residential environments [20]. Across most of Western Europe, but particularly in the UK, there is also the pressing need to increase the number of dwellings available to accommodate those in need [21,22]. This was highlighted by the House of Commons in 2010, who stated that there are wide social and economic implications in the failure to keep up with rising housing demand [23]. This is particularly an issue in 'city regions' where the settlement of people is vital to a stable regional economy. As a result, more housing is being built on redeveloped Brownfield sites, which are invariably closer to potential sources of vibration, noise and other disturbances. Such issues and factors, alongside the contemporary agenda of creating sustainable communities [24] and an emphasis on the impact of environmental stressors on health and wellbeing [25,26] highlight the importance of developing an accurate understanding of the effects that residential environments have on people, and the ways in which people respond to them.

In 2008, Defra commissioned a study into the human response to vibration in residential environments. The aim of the study was to identify an exposure–response relationship between human responses, in this case levels of annoyance, and measurements of vibration taken internally within residents' properties. The initial component of this research focused upon vibration from railways, subsequently extending the remit to construction activity and internal sources of vibration. This paper outlines the method through which the social survey was developed and reflects on the multidisciplinary approach to studying the human response to vibration from environmental sources in order to provide good practice guidelines for future research.

2. Designing a socio-vibration survey

When designing a socio-vibration survey the following should be taken into account:

- The design in relation to administration of the survey;
- The design in relation to data analysis;
- The construction of questions;
- Question Routing;
- How the survey is introduced to respondents;

2.1. Aims of the survey

The socio-vibration questionnaire aims to gather the responses of residents living near sources of vibration outside of their control. These responses have to serve for deriving exposure–response relationships for vibration in the residential environment, and therefore have to be suitable for analysis with vibration measurement data. The socio-vibration questionnaire has to allow for an in-depth analysis of annoyance by collecting annoyance ratings for all potential sources of vibration as well as for noise in the residential environment. Due to possible differences in annoyance responses at similar levels of exposure other questions around and beyond annoyance should be collected to gather information on the respondents' attitudes, situations and socio-demographic characteristics.

2.2. Design in relation to analysis

As the aim of the survey is to produce an exposure–response relationship for vibration and annoyance, as well as to study the response in a wider societal context, there are considerations to be made from each discipline and related fields in terms of good practice.

2.2.1. Administration of the survey

The questionnaire administration (i.e. contacting the respondents and delivering the questionnaire to the respondents) is likely to have different effects on the quality of the data collected [27]. The way in which the questionnaire is to be delivered to the targeted sample is of primary importance during the design stage of the questionnaire. The survey administration technique conditions the design of the questionnaire. For instance, postal questionnaires should avoid difficult routing or wording whilst personal or telephone interviews can be structured more flexibly. Therefore the designers of the socio-vibration questionnaire need to be aware of the potential effects of mode of administration on the data collected.

In general, personal interviews are seen as the least burdensome method as it only requires the respondent to speak the same language in which the questions are asked, and to have basic verbal and listening skills [27]. Moreover the personal interview has the least item non-response as the interviewer ensures to record the questions correctly [28–30]. The perception of vibration involves a large range of sensory systems therefore describing vibration to the survey respondents is not an easy task. When people are asked about vibration they often describe the associated noise and visual sensations alongside the physical sensation of feeling vibration [31]. Vibration is often accompanied by noise and 'vibration effects may be more subtle and less noticeable than noise' [31]. Residents may also be uncertain of the differences between noise and vibration [32]. Thus, the role of an interviewer that probe for responses, clarify ambiguous questions and help respondents with enlarged show cards of response choice options can be crucial to ensure the quality of the data collected.

On the other hand, face-to-face interviews as opposed to self-administrated questionnaires can lead to respondents taking social norms into account when responding, resulting in social desirability bias (the desire of respondents to present themselves in the best possible light), resulting in the over-reporting of desirable behaviours, and under-reporting of undesirable behaviours (confounding associations between variables by attenuating, inflating or moderating relationships) [27]. Responses on annoyance due to vibration are quite unlikely to result in social desirability bias as the question is considered to be non-socially sensitive. However, other questions also important to collect alongside annoyance such as health related status, quality of life or economic status could suffer from social desirability bias.

Interviews should follow a clear procedure in order to achieve randomness of the sample. For instance, for personal interviews, properties within the selected sites should be visited a number of times and different hours of the day to minimise the likelihood of missing certain socio-economic groups during the survey. Moreover, in order to prevent contamination of the questions between respondents from the same household or between people living at the same address, the survey should be designed so that only one person per household and only one household per address is interviewed. However, certain settings may influence the sample acquired. For instance, some personality traits can drive respondents to accept or refuse being interviewed. These personality traits may also be linked to annoyance. It may be the case that people who are seriously disturbed by vibrations may have moved away.

Despite the advantages of the personal interviews, most of the time this technique is considered too costly and time consuming therefore postal questionnaires or phone interviews are a preferred option. Research on vibration annoyance has used telephone interviews [33,17], postal questionnaires [34] and face-to-face interviews [35].

The way in which the survey is presented can affect the characteristics of the sample. In order to avoid influencing responses and