Limits of utility of dosage-response analysis for predicting the prevalence of annoyance.

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Summary: Dose-response analyses from field studies are essential parts of the information necessary for establishing limits for tolerable noise immissions within the sites (e.g. residential areas with certain immisions) and persons actually studied. But they have their limits when we (1) compare dose-response data between independent studies, (2) try to extrapolate annoyance data to other sites, other immission types, levels resp. numbers of noise events, other people, or future times, and (3) predict the effect of noise abatement programmes. These limitations are presented, using empirical data for illustration purposes. The discussion concentrates (a) on comparisons between different methods of measuring annoyance, (b) on comparisons between different noise sources, and (c) on predicting the effects of changes from observations on stationary noise situations. It is concluded that dose-response analyses must not be discarded, but their limited utility should be kept in mind.

INTRODUCTION

We all need dose-response relationships between variables expressing the noise load in a community and variables expressing the degree of negative reactions toward the noise in the community. The reasons for this need may be different, e.g., we may (a) just want to see the scope of the problem and say how many people are severely annoyed by noise at certain levels of numbers of noisy events, or we (b) may want to compare the effects of different noise sources at the same noise level, or we (c) may want to predict the community response in future times, when the noise load may have changed. There may be other reasons, too, but I like to stick to those mentioned here. Mostly, the dose-response data consist of energy-related data on the acoustic side (e.g., L_{Aeq}, or L_{DN}), and annoyance data on the response side (e.g., the percentage of highly annoyed respondents (%HA). Each of the three reasons mentioned may pose methodological problems if we want to apply data from one study (collected at certain sites) to other people at other sites. I like to discuss some of these problems under three headings: (1) Comparisons between independent studies, (2) Extrapolations to noise loads not included in the studies, or future times, and (3) Predictions with respect to changes in the noise load.

COMPARISONS BETWEEN INDEPENDENT STUDIES OF ONE NOISE SOURCE

In establishing noise limits which are thought to be tolerable, we often use data from different field studies. For instance, if we want to know the level of aircraft noise which leads to 25 % highly annoyed residents, we may take the study of Taylor et al. [14] at Toronto International Airport, which got 58 dB(A), the Swiss study [10] which got about 61 dB(A), and the Oslo study [4] which got about 63 dB(A) L_{eq} during daytime. These studies differ in several respects, of which only four shall be mentioned here: (a) the respondents belong to different cultural areas, (b) the studies have been made at different times in the noise history, (c) the number and types of aircraft movements are different, and (d) the response scales are different. The first three aspects have been ignored in the scientific literature, assuming that there are no cultural, historic, or type-of-aircraft influences as long as there is no scientific study testing the effects, while the number of events had shown nonmonotonic effects. The fourth aspect has been circumvented by an assumption first made by Schultz [13], that the percentage of highly annoyed people can be compared between different response scales as long as we take the maximum position on the scale as 100 per cent annoyance and use the upper 26 per cent of the scale length for calculating "highly annoyed". In other terms: In contrast to Taylor et al. [14] who considered every person using at least scale point 5 on a 9-point scale, we would count persons using at least point 7 for assessing the number of higly annoyed people; we would count persons using at least point 4 on the 5-point scale in the Gjestland et al. study [4], and we would count persons using at least point 8 on the 10-point scale in the Oliva study [10].

It should be noted that none of the instructions for the respondents said anything about the meaning of the upper or lower points of the scale. That is, the respondents were free to assign the upper end of the scale either to the maximum annoyance they ever experienced, to the maximum annoyance they could imagine, or to the maximum of annoyance they believed other people could bear - to mention but a few options. In addition, in the case of verbal scales, the Schultz-criterion ignores the meaning of the labels on the critical steps of the scales; it simply assumes equidistance between the steps without empirical evidence, and it ignores context effects of the labels on the critical steps, i.e., the influence of the meaning of the labels above and below the critical step [16]. I truly hope that some of these problems will be controlled when we use the procedures for shared annoyance questions advocated by Fields et al. [2].

COMPARISONS BETWEEN TWO NOISE SOURCES

If we compare a dose-response relationship of one source with that of another, we may run into special problems. Usually, the two sources are compared within the same study, and this secures the use of the same procedure for measuring the effects of the different sources. This time, comparability problems may arise because (a) the acoustic assessment may be more adequate for one source, but not for the other, and (b) the main effect of one source differ from that of the other source. For instance, railway noise has generally been shown to be less annoying than road traffic noise at the same energy related noise level. Usually, the number of loud events is much less in railway noise situations than in road traffic situations. On the other hand, the maximum level of railway noise is greater, and the minimum level, too. We all probably agree in saying that energy related noise levels are somewhat more adequate for road traffic noise that for railway noise, because road traffic noise often assumes the quality of continuous noise, while railway noise is more discontinuous.

If there are differences in the character of two noise sources, we may predict differences in the quality of noise effects, too. For instance, Fields & Walker [3] report speech interference problems to be the most important noise effect, and vibrations to be the most important non-noise problem of railway situations. Schuemer & Schuemer-Kohrs [12] report greater nighttime disturbances for road traffic noise than for railway noise. In addition, the slopes of the dose-response relationships are different for railway and road traffic noise. Altogether, the empirical evidence points to severe comparability problems of dose-response relationships between different noise sources.

PREDICTING NOISE EFFECTS IN FUTURE SITUATIONS

Dose-response relationships often are used in order to predict noise effects in future situations, e.g., after installing a noise abatement program. In former times, the predictions were rather naive: It was believed that respondents in changing situations would react like respondents in stationary situations. Meanwhile, predictions are rather cautious, because (a) it seems that respondents today are somewhat more annoyed at similar noise levels than respondents some years ago, (b) a short-term decrease of less than 6 dB(A) noise level does not have significant effects on the number of highly annoyed residents, wile a short-term increase of very few dB(A) noise level does increase noise effects significantly, and (c) even the expectation of a negative change - without any physical change - may increase noise effects.

(a) Airport authorities like to support their demand for increasing the traffic volume by stating that the noise level of individual aircrafts decreased in the past years, and at some places, the overall aicraft noise levels (expressed in L_{eq}, or D_{NL}) did really decrease. On the other hand, the number of aircraft events increased, and the number of low-noise epochs decreased. Generally, residents in the vicinity of airports do not seem to notice small decrements of noise levels [15], sometimes they even react more strongly to similar noise levels today than they did before [8]. This sheds some doubt on the belief that dose-response relationships which have been established 10 years ago are still valid for predicting the annoyance in the future. In addition, the percentage of medium annoyed people in the general public tends to increase over time, while the percentage of highly annoyed persons rests at a constant level, at least in The Netherlands and in Germany.

(b) Empirical studies on the effects of any change of noise levels, or noise composition on residents are rare, and they are difficult to perform, because retrospective annoyance judgments are subject to memory bias [1], and the expectations of residents about the effects of change often are not realistic [9]. In addition, their answers may tend to "exaggerate" because of interview-demand characteristics [7]. In a review of the effects of noise level changes, Vallet [15] showed that level decrements which are less than 6 dB(A) will not be be reflected in the percentage of highly annoyed. Raw & Griffiths [11] show that Mean Annoyance (the mean of raw annoyance scores) may be significantly changed by level changes in the order of 3 dB(A), and the effect of changes may be visible up to 9 years after the change [5].

(c) Recently, a study at Sydney International Airport [6] showed differences in self-reported physiological noise reactions to be dependent on noise expectations of the residents: Before any actual change in the flight paths of the airport had been installed, residents expecting a positive change (less noise) reported less physiological symptoms than residents not expecting a change, while residents expecting a negative change (more noise) reported more symptoms. This again points to the limited value of merely looking at dose-response relationships; it also underlines that noise effects are moderated by variables which are not reflected in acoustic measurements.

CONCLUSION

Dose-response relationships are necessary in order to know the extent to which an acoustic description of the noise situation relates to reactions in the community. But it should be kept in mind that the statistical association between dose and response seldomly exceed 30 per cent, and that it may be significantly influenced by measurement aspects of both the noise and the noise effects, by the type of noise, and by history effects. It would be especially dangerous to predict future noise reactions from observations in static situations.

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