INSTITUTE OF ACOUSTICS MEETING ON URBAN NOISE
MEASUREMENT AND EVALUATION, 13/14 NOVEMBER 1973

THE CASE FOR A UNIFIED APPROACH TO THE ASSESSMENT OF LONG-TERM UNSTEADY NOISE EXPOSURE

J. B. OLLERHEAD

LOUGHBOROUGH UNIVERSITY OF TECHNOLOGY

Summary

It is suggested that the present proliferation of community noise scales may be attributed to the narrowness of the objectives of the many studies which have generated them. There is probably little to lose and much to gain by pursuing a more unified approach to long-term noise measurement and the current state-of-the-art appears to provide a satisfactory point of departure.

1. Introduction

One of the main obstacles to the control of noise pollution is the difficulty of setting noise standards. This in turn stems from the problem of measuring noise exposure in terms which can be relative to human response. In their extensive and diverse attempts to overcome this problem acousticians have actually magnified the problem and there can be little doubt that to the lay observer the entire field of noise assessment is one of utter confusion. Although it is fairly easy to explain the differences of expert opinion, it is not so easy to satisfy the authorities responsible for environmental control that progress is in fact being made.

Three kinds of noise can be identified; (i) long-term steady noise; (ii) short-term unsteady noise and (iii) long term unsteady noise. The subjective aspects of each of these has been studied somewhat independently of the rest, indeed they give rise to different kinds of problems and there is a good reason for doing so.

In general, people adapt fairly readily to long-term steady noise, examples being of the hum of ventilation equipment, factory machinery or even the general conversation level in a large office. This kind of noise normally creates a problem only when it interferes with speech communication, or physically endangers the hearing function. It is now common practice to evaluate these possibilities by measuring the steady noise level on the A-Weighted sound pressure level or L(A) scale although procedures such as Speech

Interference Level (SIL) and Noise Rating (NR) indices are available alternatives.

There is a much greater probability that noise will be judged a nuisance when it is unsteady, that is when its character changes with time. The more unsteady the noise, the more likely it is to attract attention to itself and disrupt human activity. The simplest form of unsteady sound is the short-term single-event such as the sound of a vehicle pass-by which rises to a peak level and declines fairly rapidly. Many studies have been made of the factors which influence the perception of single events and these have given birth to a multitude of basic noise rating Scales including Weighted Sound Pressure Levels, Loudness Levels and various forms of Perceived Noise Levels. It is now generally recognised, however, that in terms of predictive accuracy there is little to choose between the numerous alternatives and there is a growing consensus that one may as well settle for the most convenient. Again, the L(A) scale is gradually displacing alternative options for measuring short-term noise levels from all sources.

The area where agreement has still to be reached concerns the measurement of long-term unsteady noise, or 'noise climate'. Most community noise levels vary with time and, particularly when transportation is the source, the fluctuations may be very large. It is often convenient to consider this situation as a large number of single events superimposed upon some quasi-steady background noise and this too has been the subject of considerable study. Numerous techniques have emerged for scaling noise climate, although the differences stem from intentionally different applications, rather than different solutions to the same problem. Typical procedures include L_{10}, TNI for road traffic noise, NNI, NEF and WECPNL for aircraft noise, and CNL, L_{NP} and L_{eq} for other noise of a more general nature. There are many other alternatives.

There is now a general feeling amongst noise researchers and practicioners that the distinctions between these various schemes, and of more importance, their ability to predict human response, is not at all clear. With increasing frequency the question arises of whether or not some degree of unification is possible; certainly the advantages of a unified approach to long-term noise assessment are clear. The confusion and opportunities for misapplication would diminish. Measuring instrumentation and analysis techniques could be standardized. The approach to mixed noise situations (e.g. road traffic and aircraft) would be clarified. The results of different research studies and surveys would be compatible and allow the accumulation of a large and comprehensive data bank. Perhaps of most importance, some order and confidence in the field of noise evaluation might be restored. What then are the possibilities for such a unification?

2. Background to the existing diversity

Before examining the implications of this question it is necessary to consider the reasons for the present proliferation of techniques. There are two major contributing factors. The first is that different noise problems have been tackled by different people, in different ways and in different places. The second is that effort has been devoted to a search for methods to predict human responses, which are influenced strongly by stimuli other than noise. The difficulties that were bound to arise may be understood by reference to Figure 1, which depicts the relationships between the primary factors affecting these responses. Working from left to right in this diagram, the receiver's 'response' to a given noise climate may be divided into two distinct and sequential stages (1) disturbance and (2) annoyance. If he is not concious of the noise, he has no response to it and the first stage depends upon detection or awareness. This is largely influenced by physical and sensory factors which are well documented; it is thus reasonable to suppose that, ignoring the essentially small difference in individual hearing acuity, the possibility of disturbance is highly predictable from a consideration of the relationship between the intruding non-steady noise or signal and the familiar steady background noise to which the listener has adapted. If the noise has attracted the listener's attention, the chance that it will interfere with his activity, i.e. cause and disturbance depends upon that activity. If the individual is engrossed in some stimulating mental or physical activity, for example, he is less likely to be disturbed than if he were relaxing, watching T.V., or engaged in conversation. Thus, to preduct disturbance, some knowledge is required of both awareness and activity. Individual activity is clearly difficult to predict, but for a particular type of neighbourhood, e.g. rural, suburban, residential, commercial, industrial etc., and time of day, particularly day, evening or night, an estimate of typical activity can surely be made. However, even taking this into account, disturbance will be less concerned with noise exposure than the first stage of response.

Once the individual has been disturbed, the probability that he will be vexed or agitated, that is annoyed depends to a significant extent upon a variety of intervening external factors. These include, in addition to activity, his attitudes towards the source, especially his opinions about the necessity for the noise and its preventability, his previous exposure to it, any personal association with the noise generating activity, whether or not there is any implied physical danger and feelings that the originator may be acting irresponsibly or negligently. These factors may in fact influence his annoyance to a greater extent than the magnitude of the noise itself. Unfortunately, these too, are largely impossible to estimate. In very general terms, for the purposes of predicting mean annoyance levels, they may be related to the type of neighbourhood and specific noise sources involved but differences between people will be large and annoyance correlated with noise to an even smaller extend than disturbance.

This logic suggests that any attempt to predict individual annoyance from estimates of the noise exposure alone is likely to be unsuccessful. Since most studies of community response to noise have had precisely this objective in view, we have had many demonstrations that this is indeed the case. There are two main conclusions to be drawn. The first is by considering the noise alone, it is only possible to predict the possibility of disturbance or annoyance, further information about the intervening factors being required to estimate likely response levels. Even with this, it may only be possible to predict mean response, accepting that individual responses are widely distributed about the mean. The second is that this large inter-subject variability will totally mask the relative merits of different noise scaling techniques.

This second conclusion explains the multiplicity of existing noise rating procedures in that practically any device, provided it measures some salient feature of the noise will be equivalent to any other in its ability to predict annoyance response. The fact that characteristically different scales have emerged from the various studies, may be attributed to different methodoligical approaches and the requirements of convenient measurement. For example, in the case of road traffic noise, involving many thousands of single events, it is more convenient to measure L_{10} with a distribution analyser than to follow the aircraft noise practice of averaging peak levels. The significant differences between the various schemes may be found in their interpretations which are implicitly specified for particular noise problems, e.g. aircraft noise, road traffic noise, industrial noise etc. These differences in fact reflect allowances for the 'intervening factors' of Figure 1.

3. Possible courses of action

We may now turn to the question of whether or not a unified noise rating scheme is a practical proposition. Itmust first be stated that if the objective is to establish a common noise index which, when applied to any kind of noise, will predict mean response or a distribution of responses, the answer must be negative - unless the index includes allowances for the intervening factors. This may be compared with the idea of developing a thermometer which weights its temperature reading in accordance with its location. For example, in the home, by a swimming pool or in a fresh fish shop. Such an elaboration appears to be unnecessary, since its user is capable of performing the necessary interpretation.

In the author's view, we should be satisfied with an index which simply predicts the potential for annoyance, estimating actual annoyance distributions by considering extraneous factors at the interpretive stage. Within these limits the prospects for unification seem to be good. Figure 2 is an example of the sort of approach which might be adopted in the short-term. This is specific to the aircraft noise problem (Ref.1) and shows the distribution of annoyance as a function of noise level expressed in NNI units. This diagram is strictly limited to the prediction of noise impact near major international airports where about 80% of aircraft movements occur during daytime. However, recognising that the noise scale may be converted to any suitable (unified) index, the diagram may be thought of as an interpretation for one particular combination of intervening factors, that is those associated with aircraft noise, major airports, suburban residential neighbourhoods, and daytime. Any other combination of factors would require different interpretations. These might require different curves, perhaps simply a lateral shift of the presented curve.

The immediate problem is the selection of a suitable noise index, which would be acceptable to all interested parties. The acoustic characteristics which experience and laboratory experimentation suggest should be taken into account are the ambient noise level, peak signal levels and typical temporal variations of single events, and the frequency and intermittency of their occurrence. The latest version of Dr. Robinson's Noise Pollution level (Ref.2) satisfies may of the requirements but mathematical completeness has to be balanced against practical utility. It is probable that a modified version of this which makes concessions for the convenience of measurement and analysis would find widespread favour.

In the long-term further detailed study of the interrelationships depicted in Figure 1, could shed a great deal of light upon the problem of community noise evaluation. However, in view of the desirability for a degree of unification, this possibility should not be allowed to delay efforts to achieve it.

References

1. Ollerhead, J.B., "Estimating the Nuisance Caused by Transportation Noise". Paper C.14 Proceedings of the Symposium on the Enviroment and Transport Technology, Loughborough, September 1973.

2. Robinson, D.W., "An Essay on the Comparison of Environmental Noise Measures and Prospects for a Unified System" N.P.L. Acoustics Report Ac 59, October 1972.

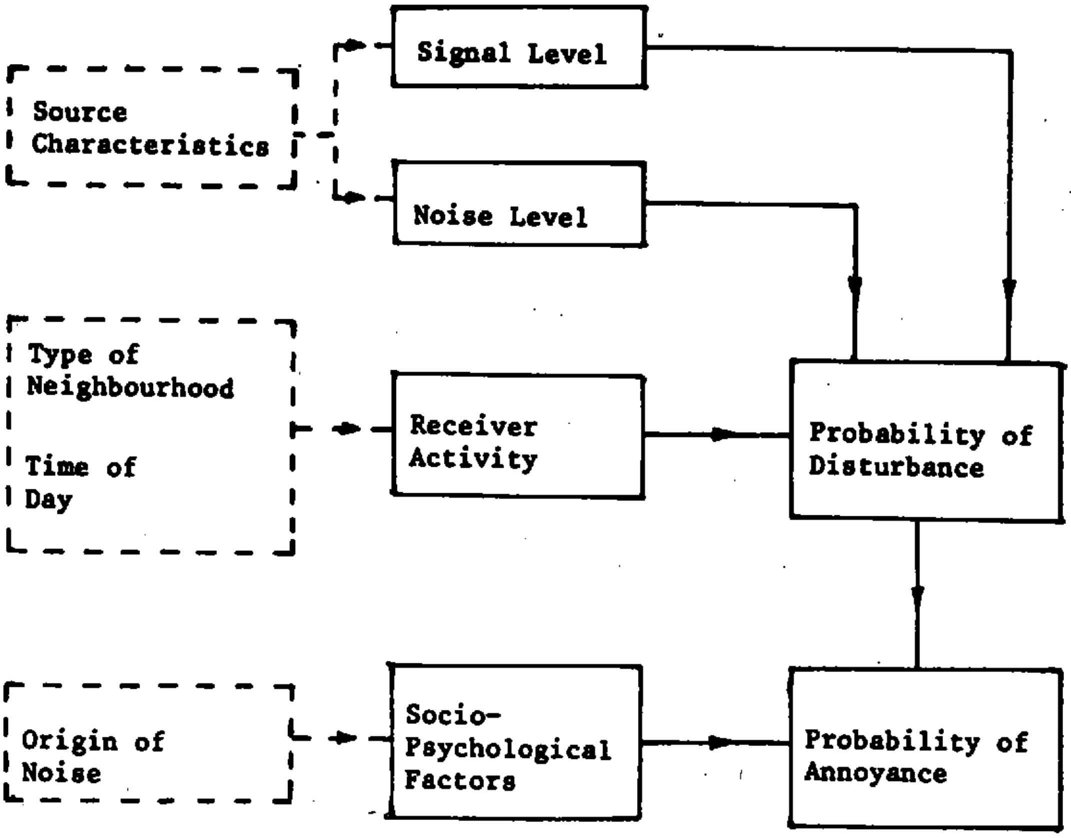

Figure 1. Noise Reaction Model.

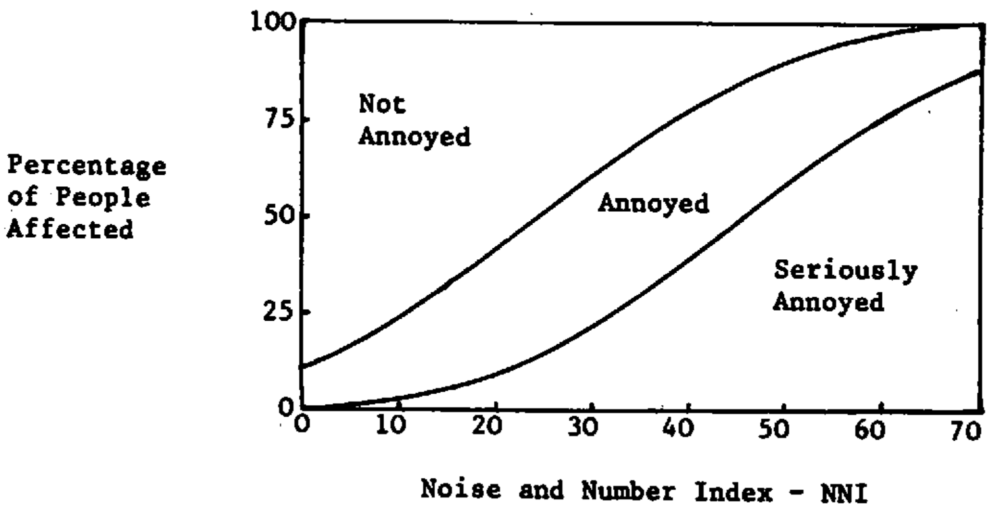

Figure 2. Reaction to Aircraft Noise.