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Acoustical determinants for annoyance reactions.

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1. Introduction

The purpose of the presentation is to review the relation between noise exposure and the effect in humans and to discuss a new concept derived from experimental studies on noise exposed populations.

2. The exposure

Noise exposure is a combination of several physical factors. The number of exposures, their duration, the frequency spectrum and the rise time of the energy front are some of the more important physical characteristics. It has been shown in laboratory as well as field experiments that several of these are important for the development of an exposure reaction in humans. One has thus tried to include the relevant characteristics in various indicies to express the noise exposure. Concerning community noises these are usually constructed according to the acoustical principle of equal energy and contain expressions for the number of exposures as well as some mean of the noise level.

3. Environmental noise exposure effects.

Exposure to community noise at levels commonly found in the environment will not, according to available epidemiological or experimental evidence, cause any long term effects on hearing. The effects are related to disturbed activities, such as speech and sleep or interference with rest or recreation. Certain noises will also cause startle effects which might lead to fright reactions.

The exposed person might experience the disturbance of his activities as interfering with his wellbeing and his reaction will then be to express annoyance. In a single individual, annoyance reactions are to a large extent determined by extra-expositional factors, such as the socio-economical status, awareness of the exposure and psychological reactions on an individual basis. The correlation between an exposure and individual annoyance is therefore never very high. The mean reaction in a group of representative individuals is well correlated to the exposure agent and reproducible from one investigation to the other. From the public health point of view, the mean reaction must therefore be used if annoyance reactions in a population are to be used as criteria.

The presence of annoyance reactions is assessed with the aid of social survey techniques, where the aim of the investigation is not revealed to the respondant. This masking effect is obtained by introducing questions on a variety of environmental annoyance sources in the questionnaire. The investigation must be performed at times when publicity or public awareness of the annoyance source investigated is not unusually high.

For the evaluation of the annoyance reaction a variety of methods have been suggested. Annoyance scores have been constructed using the answers from the different questions on the exposure effect . In other surveys the total assessment of the annoyance is used to evaluate the severity of the effect.

Concerning the mean reaction in a group of people, it has been shown that the construction of complex annoyance scores or response scales will not improve the accuracy of the evaluation. A danger even exists that the accuracy will decrease if questions which are less relevant for the reaction studied are included.

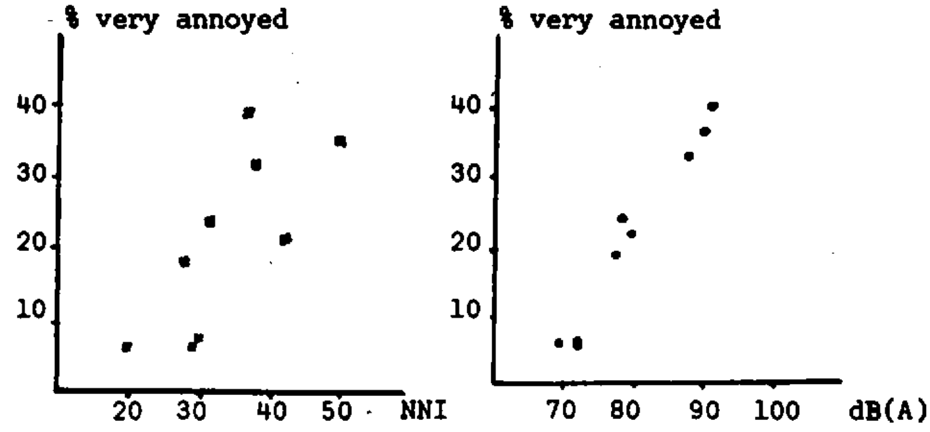
4. Aircraft noise

Concerning aircraft noise a relatively good correlation has been demonstrated between different indicies based on the equal energy principle and the extension of annoyance in exposed communities. In several of the studies however the development of the index has been performed against the background of available experimental data and weighting factors for various components of the index have been inserted by adapting the index to the already existing response pattern. At this stage the index must therefore be looked upon as a working hypothesis derived from an experiment and has to be verified in renewed studies. When such studies have been performed, it has often been found necessary to modify the original index by inserting other weighting factors than those originally suggested. Furthermore, the experimental design of several investigations have strongly favoured the concept of the equal energy principle.

A different approach concerning the noise exposure was taken in a Scandinavian investigation concerning aircraft noise annoyance performed 1969-1972. In this investigation the number of aircraft movements and the noise level in dB(A) were kept separate and studied as independent variables . Variations were obtained by choosing investigation areas at different distances from the airport and by studying different airports with a large traffic variation.

The results from this investigation indicated that the exposure frequency is of importance to classify the areas in different exposure categories. A maximum was however reached at about 50 aircraft-exposures / 24 hours. A further frequency increase did not augment the extent of annoyance at equal dB(A) levels.

Within each exposure category the extent of annoyance was closely related to the dB(A) level from the noisiest aircraft using the airfield. The results from areas exposed to 50 - 189 aircraft movements per day are demonstrated in figure 1, where the extent of annoyance is related to the max. dB(A) concept as well as the NNI levels.



It is seen in the figure that the correlation between annoyance and exposure level was considerably higher for the max. dB(A) value.

5. Practical application

The application of the new principle for the control of aircraft noise involves several important consequences in comparison to the present practice using equal energy indices.

When a standard concerning the accepted extent of annoyance in the community has been set, the critical noise contour around an airport is drawn,using information concerning the dose-response relationship between the noise exposure and annoyance. This applies both to equal energy indices and the new principles. According to the latter however, it is the dB(A) contour from the noisiest aircraft that constitutes the critical noise contour. If the noise level from the noisiest aircraft at the airport is reduced for instance by engine retrofit or by phasing it out of service, the critical noise contour will move to the next noisiest aircraft type, even if the total number of movements remains the same, or - for areas exposed to more than 50 flights / 24 hours - increases.

Practical evaluation of the new principles around a variety of airports shows that the two concepts - equal energy indices and max. dB(A) - give relatively similar initial noise zones in many cases.

In certain areas however, they differ widely. At one medium size European airport about 2.5km^2 are not covered by the equal energy index although it falls within the limits of the dB(A) contour. With densely populated regions near airports, this represents a significant number of people who will receive an exposure which was not accounted for when the value for NNI was accepted.

As the new principles imply important consequences from public health point of view, it is naturally interesting to test further the validity of the hypothesis developed in the Scandinavian investigation.

The full paper will report results from the re-analysis of investigations performed earlier, where the original data were available in a form which made it possible to determine for each investigation area the number of overflights and the noise levels from the noisiest type of aircraft. The possible implications for the new hypothesis concerning other environmental noises will also be discussed.