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EFFECTS OF NOISE ON PEOPLE

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The effects discussed in this paper have been grouped under five headings - impairment of hearing, effects on performance and efficiency, measures of disturbance, speech interference and the possibility of beneficial effects due to masking.

I Impairment to hearing

The very high levels of noise which can cause immediate damage to the ear are not normally encountered in ordinary life, but a gradual deterioration in hearing can occur by exposure to loud noises over a long period of time. The degree of permanent damage apparently depends on a combination of the level of the noise and the length of exposure time, and for an eight-hour working day over a period of some years, a noise level of 90 dBA should not be exceeded. If the level is 100 dBA, the maximum exposure time should be reduced to 50 minutes per day. Temporary threshold shifts can occur at lower levels of noise and exposure time.

II Interference with performance and efficiency

Work in recent years has demonstrated that tasks which require alertness (i.e. tasks which are not composed of repetitive actions), are performed with less efficiency in the presence of noise levels of 90 dBA and above (1). This applies to tasks which have a long duration, and it is suggested that the noise causes a "blinkering" effect, the unexpected event being missed. However under certain conditions such as a task which has little activity or an observer suffering from lack of sleep, noise can be beneficial by acting as an "arousal" agent.

III Measures of disturbance effects

The intensity of a noise is an obvious consideration in determining the degree of disturbance or nuisance caused by the noise, but by itself it is not sufficient. Different sounds of the same intensity do not provide equal loudness sensations, and the characteristics of hearing with respect to frequency have to be considered. This subjective property is measured on a loudness level scale in phon units. Methods of calculating loudness level from the spectral distribution of the noise have been standardised (2): one of the methods due to S.S. Stevens (3) uses the data in octave bands, while the other due to Zwicker (4) applies where one-third octave band data are required to describe the noise spectrum adequately. The method of calculation has to be specified in quoting a result.

However, loudness considerations do not include all the factors which determine how disturbing a noise will be. Some of the other main considerations in assessing this degree of disturbance are as follows:

The difference between the level of the offending noise and that of the general ambient surroundings.

The variation of the level with time on a short-term basis (over

periods of seconds or minutes).
The presence of any tonal components in the noise.
The presence of any impulsive irregularities in the noise.
The time of day and of the year.
Does the noise have any meaning? Does it contain information?
Is the noise preventable?
Some of these items have been incorporated into the various measures which have been proposed for use as criteria, and the most important of these measures are described below.

dBA. A measure of sound level in dBA units has been found to give reasonable correlation with subjective assessments. This has frequently been in the form of the mean value - L_{50} (the level which is exceeded for 50% of the time), but L_{10} is being used in many instances now (5, 6, 7, 8). This, as the level which is exceeded for 10% of the time, can be considered as the average of the peak values. Frequently for work in connection with road traffic noise L_{10} is being considered for a particular part of the day, and Scholes and Sargent (9) have recently proposed this for the period 0600 - 2400 hrs. L_{90} is often taken as a measure of the general background noise.

However, consideration of the increase in sound level caused by the traffic noise above the average background and correlation studies using a survey made in residential areas near busy roads, have resulted in the formulation by the Building Research Station of a Traffic Noise Index (TNI) which is a weighted combination of L_{10} and L_{90} levels (6, 7).

$$TNI = 4(L_{10} - L_{90}) + L_{90} - 30$$

This measure was originally prescribed for a period of 24 hours, but it has been used in subsequent work for shorter periods of time.

Another measure particularly related to road traffic noise is the Noise Exposure Index developed on the continent, and it is frequently evaluated in the form of the mean energy level. It is the equivalent continuous noise level leading to the same total noise exposure on an energy basis (10).

Noise Criterion Curves (11) and Noise Rating Curves (12) are two series of curves specifying a set of maximum permissible sound pressure levels according to octave bands of frequencies. They are similar in form, NC curves being of American origin, and NR curves of European origin. The latter set of curves is under consideration for adoption by the International Organization for Standardization (ISO).

For aircraft noise in particular, Kryter developed the measure of Perceived Noise Level (13) similar in concept to the loudness evaluations but based on subjective assessments of "noisiness", and expressed in PNdB units. Corrections have subsequently been proposed to allow for the presence of tonal components and for the variation of the intensity and frequency characteristics with time during the flyover.
A weighting network D having increased emphasis for frequencies above 1kHz, has been introduced recently into sound level measurements to provide an approximation to the PNdB value.

$$PNdB \doteq dBD + 7$$

The effect of a number of aircraft flyovers has generally been assessed in this country by means of the Noise and Number Index (NNI) which was developed from an analysis concerned with the social and noise surveys made around London Airport about ten years ago (5). This measure of community disturbance is a combination of the average peak noise level and the number N of aircraft heard during one day or night.

$$NNI = \text{average peak noise level} + 15 \log N - 80$$

The average peak noise level is the average of the maximum values,

in PNdB, during the passage of each aircraft.
The NNI method and the values which have been used for the determination of the degree of disturbance may have to be modified following the second survey made in 1967: the results have only recently been published (14), but one of the suggestions is that people have acquired an increased tolerance to aircraft noise, and may have become "acclimatised" to a certain degree.

Recently, Robinson of the NPL has proposed the use of the concept Noise Pollution Level (L_{NP}) as a general measure of disturbance to cover most types of noise (15, 16). This is a combination of two terms, one being the equivalent continuous noise level on an energy basis, and the other representing the degree of variation of the noise level. A basic formula is

$$L_{NP} = \overline{Q} + 2.56\,\sigma$$

where σ is the standard deviation of the instantaneous level over the period used to evaluate the "energy mean" $\overline{Q}$.
A form which has been used for road traffic noise is (17)

$$L_{NP} = L_{50} + d + d^2/60$$

where d = interdecile range ($L_{10} - L_{90}$).

British Standard 4142 (18) describes a method of rating noise of industrial origin in order to determine whether it will give rise to complaints by persons living in the vicinity, and is concerned with the margin by which the noise level exceeds the pre-existing background noise or its equivalent. A measurement of the noise is corrected according to its tonal and impulsive characteristics and to its intermittency and duration: this is then compared with the background noise level, or, if this can not be obtained, with a criterion which takes into account various environmental factors such as the type of neighbourhood and the time of day (and of the year) when the noise occurs.

IV Interference with Speech

This effect is one of the most important factors in producing annoyance to people. The most favoured predictor of speech intelligibility to-day is the Articulation Index, AI. The original work (19) has been modified and adapted subsequently, but it is based on a division of the speech spectrum into 20 unequal bands, each making an equal contribution to the intelligibility of speech. The spectrum of the noise is compared with this, taking note of the level of the speech and of the talker-listener distance. The AI is the fraction of meaningless phonetically balanced syllables correctly interpreted by the listener, but the intelligibility of sentences is of course much higher. An AI of 0.6, which is often used as a recommendation, corresponds to word intelligibility of greater than 83% and sentence intelligibility of greater than 95%.

An approximate index of speech intelligibility is the Speech Interference Level (SIL) which is associated with the NC (or NR) curves (11, 12). In its simple form, this is the arithmetic average of the noise levels (dB) in the three octave bands with centre frequencies 500, 1000 and 2000 Hz.

V Masking Effects

There is a growing amount of evidence that some acoustic environments are considered to be unsatisfactory because the general background noise level is too low. Under these circumstances some annoying or disturbing sounds can become more noticeable and there is a lack of acoustic privacy. This is particularly applicable to hospital wards, where the sounds of illness and treatment at other beds can be very disturbing, and confidential conversations with the medical staff can be overheard. In arriving at a satisfactory solution, a suitable balance between masking and acceptability has to be obtained. Work which we are doing at University College London indicates that some forms of road traffic noise can be an acceptable mask: the noise must be reasonably continuous, and preferably with only a small amount of articulation. Ventilation noise up to a certain level can also be useful. This technique of using masking noise principles in the design of environments is finding application in many fields including open-plan offices and schools.

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