MEDICAL PRACTICE

Pollution and People

Noise: hearing loss and psychological effects

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After one of the noisiest nights I have ever spent, one morning in 1957 I saw banners being raised over the streets of Zürich bearing the words "Die rühige Stadt hat wenige kränken." But whether "the quiet city does have few ill people"—or the noisy one many sick—is harder to prove than the effects of noise on hearing.

The damage to hearing caused by intense noise has microscopically visible effects on the inner ear and is related to the intensity, nature, and duration of the noise.[1] Studies of occupational hearing loss[2] have led to scales of maximum noise exposure—for example, in Britain, 90 dB(A) average continuous noise (L_{eq}—see box) for eight hours per working day, or 96 dB(A) for two hours: this is known as the equal energy principle. Nevertheless, such levels are not safe especially if they extend over a working lifetime: in particular, individuals vary in their susceptibility to damage, and the effects of age and pathological conditions add substantially to those of noise.[3] The British code of practice emphasises that the limits are the "maximum acceptable" rather than "desirable" and that where practicable noise should be reduced to lower levels.[4] An L_{eq} of 80 dB(A) for an eight-hour day would largely remove the hazard[1]; and the United States Environmental Protection Agency has recommended as a long-term goal 75 dB(A) L_{eq}, with 70 dB(A) averaged over the 24 hours.[5]

Apart from explosive sounds such as gunshots, non-occupational noise in general probably does little if any damage since exposure is normally limited. Added to occupational exposure, however, it could be important[6] (table); and using powered tools at home, for example, could then call for ear protectors. Listening to hi-fi at home may also add to the noise dose. But discotheques and pop concerts are the most worrying. A pop concert might register an L_{eq} of 109 dB(A) over two hours on a personal dose meter.[7] In a recent survey of discotheques a mean level of about 97 dB(A) L_{eq} was recorded on dose meters, with much higher peaks.[7] Some 10-12% of attenders had noisy jobs. On the basis of the data on attendance about 1500 out of an estimated 6 million disco attenders, it is calculated, will develop a permanent hearing loss sufficient to interfere with conversation, and more a higher-frequency loss. The Noise Advisory Council recommends that a code of practice should be drawn up and the possible risks made known to attenders.

Measuring noise

Noise is usually measured in decibels (dB) on a logarithmic scale expressing the ratios of particular sound pressures to a reference level (0 dB). A doubling of sound pressure is an increase of about 6 dB; but subjectively an increase of 10 dB, on average, makes a sound twice as loud.[1] The commonly used A scale (dB(A)) incorporates a weighting to take account of the ear's varying responses to sounds of different frequencies. There are many noise indices, including dB(A) L_{eq} (the continuous equivalent sound level or average over a given period) and dB(A) L_{max} (the peak level).

Since susceptibility to damage varies, a predictive test would be useful—possibly based on the temporary change in the threshold of hearing (threshold shift) caused by auditory fatigue after intense noise; but no reliable method has so far emerged.[1] Brown eyes appear to be associated with greater resistance to auditory fatigue than blue eyes.[8] Some evidence that the permanent hearing threshold might be more affected by noise in blue-eyed people has appeared recently[9] and is being followed up. There is no proof of cause and effect; since melanin in the cochlea might be protective[8] the idea is interesting, but should be treated with caution.

If intense noise can cause appreciable hearing loss, can moderate noise cause a modest loss—and should we try to cut

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down the general noise of our lives (table)? A study of the primitive Mabaan tribe of the Sudan suggested that their hearing showed little of the usual deterioration with age; but they differ from us in many ways besides the absence of loud or prolonged noise, and in particular were found to have little if any increase in blood pressure—or presumably atherosclerosis—with age.[10-12] The subject has aroused considerable controversy[13]; good evidence one way or the other is likely to be hard to obtain.

Examples of some everyday noise levels (recorded with CEL-175 Precision Integrating Sound Level Meter by courtesy of Computer Engineering Ltd)

	dB(A)*
Motorbike going past	87 L_{max}†
Lorry going past	85–91 „
Bus going past	88–92 „
Walking along London main road	73–81
Walking through London park	60–63
Sitting on Hampstead Heath, North London	43–52
Quiet office (3rd floor), window open	44
window open, pneumatic drill outside	71
window closed, „ „ „	55
Inside mini	78
Inside mini on motorway	87
Inside suburban train	75
Inside underground train	82
Inside bus	68–76
Crowded restaurant } (no music)	78–84
Pub } (no music)	79
Motor mower (walking beside operator)	92
Hi-fi (home) } pop	≤87
Hi-fi (home) } classical orchestral (forte)	≤82
TV:news; film (a Western)	66

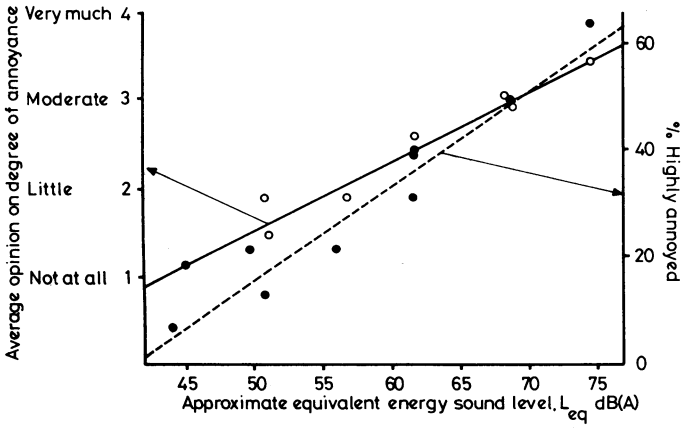
*L_{eq} unless otherwise stated.
†Measurements taken about 3–5 m away.

Annoyance

Precisely what constitutes "annoyance" in response to noise is problematical.[14] The US Environmental Protection Agency has based its recommendations specifically on interference with speech and also on complaints[5]; but usually annoyance is taken to include feelings of "bother," interference with activities, and minor psychosomatic symptoms such as headaches, tiredness, and irritability.[15]

However annoyance is defined there is great individual variation (figure), and clearly it does not depend only on the physical features of the noise: the nature of the source, the circumstances, and the characteristics and attitude of the individual are all important.[16-18] For example, in flats the noise from other people's children has been shown to be more annoying than from one's own children, despite the sound attenuation between flats.[19] Preventable or unnecessary noises and those that are meaningful tend to be the most disturbing; while a helpful attitude by those concerned may reduce annoyance. It can be lessened by good public relations—for instance, the annoyance caused by railway maintenance work at night has been reduced by advance explanations (J Walker, personal communication). Thus physical measures of noise on their own may either underestimate or overestimate people's distress. Age, sex, and socioeconomic status do not have a consistent influence on annoyance,[15] though the higher socioeconomic groups may complain and take action more; but in a population sample in the environs of Heathrow Airport middle-class people were more likely to be "bothered" by the aircraft noise and noise in general.[20]

Individual variation is strikingly illustrated by a London survey in which, at home, outdoors, and at work respectively, 56%, 27%, and 20% of people were disturbed by noise while 41%, 64%, and 70% noticed it but were not disturbed (the rest did not even notice it).[16] Even at 45 dB(A) L_{eq}, when the "average" opinion is "no annoyance," 10% of people are highly annoyed (figure)[18]; while 20% are not bothered even by living in very noisy conditions (though these may be unrepresentative of the general population).[21] But clearly the proportion of people annoyed rises with the intensity of the noise, and the proportion failing to acclimatise to it also increases—from a quarter to a third in the Heathrow study.[20] A survey carried out near John F Kennedy Airport, New York, found about the same "mean annoyance" at night as by day despite there being half as many flights at night.[22] Sleep disturbance obviously contributes largely to annoyance but has wider effects, which will be discussed in the next article.



Community annoyance in response to noise: while annoyance increases with increasing noise there is a wide range of individual variation. Reproduced from Large[16] by courtesy of the *Royal Society of Health Journal*.

Noise and mental health

Introverts cannot tolerate such loud noise as extraverts, and may actually hear quieter sounds; while anxious people tend to judge sounds to be louder than the non-anxious,[14] and neuroticism and predisposition to mental disorders have been claimed to be linked with sensitivity to noise.[23] Psychoanalysis moreover has shown that noise may be experienced as terror, bodily pain, beating, or annihilation[24]; but can it cause mental illness? Analysis of mental hospital admissions from the vicinity of Heathrow Airport and from control zones have given conflicting results; the latest conclusion is that noise is not an important cause of admissions.[25] Studies of psychiatric symptoms in other noise-exposed groups have yielded varied results.[15] Apart from the problem of matching populations or groups for comparison, such people might be expected to be unusually resilient about noise.

One of the survey methods used in the Heathrow region was the use of the General Health Questionnaire, in which about two-thirds of high scorers have confirmed psychiatric illness and one-third milder symptoms not qualifying as illness. In general, high scores were associated not with noise as such but with being annoyed by noise.[15] Preliminary analysis, however, suggests that exposure to noise was significantly associated with psychiatric disorders among people of high education or in the professions —the excess being of mild symptoms, not confirmed cases. The conclusion is that while both mentally disturbed and normal people are annoyed by aircraft noise the former are more likely to be very annoyed, and also to show annoyance in low-noise areas: the psychiatric disturbance may produce both sensitivity to noise and expression of annoyance. What is not clear from the data so far is whether excessive noise and the build-up of annoyance may be a primary cause of psychiatric disorder, at least of a minor nature.

Other psychological effects

The effects of noise on work performance, which have been the subject of extensive experimental and other studies,[19 26] are not all adverse. In general, noise increases arousal and, like other stimulating conditions, focuses attention on the dominant or

obvious features of the task or circumstances at the expense of the subsidiary or more subtle aspects. Thus it may help concentration and (at least under 95 dB(A)) improve the performance of a straightforward and narrow task, particularly in unstimulating conditions or if the person is sleepy, unmotivated, or highly extravert—though it may be detrimental to someone who is already very alert. Similarly, it has good as well as bad effects on memory: intentional memorising may be improved, but the incidental aspects of what is being learnt are neglected.

Complex tasks and complex intellectual functions, however, deteriorate; and accuracy and the response to the unexpected suffer.[26] A change in noise level appears to be particularly disturbing. The real-life effects of reducing noise levels, however, tend to be hard to prove as other things, including motivation, are likely to improve at the same time, though a fall in accident rate has appeared to be a genuine effect.[19 26]

Some disturbing consequences of loud noise, including increased aggression, have been found in experiments on social and interpersonal reactions.[26] Again the response is to the dominant features, to the neglect of the complexities of personal interaction. One study suggested a reduced tolerance of differences in others among those who were normally tolerant[27]; while another experiment suggested that people became much less likely to help others in noisy conditions (see box), possibly owing to reduced "peripheral" awareness.[28] Noise may also have harmful after-effects, socially as well as on work performance; for example, steelworkers had more domestic disputes if they were working in noise.[26]

Clearly there are many uncertainties about the effects of moderate noise, below the level that may harm hearing. But at the least there is good evidence of annoyance sufficient to affect wellbeing and in the widest sense health—with pointers to other effects, some of which will be discussed in the next article.

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This is the first of a series of articles on pollution and the community.

Noise and behaviour

Does noise make people less aware of others? In an experiment carried out in the street, one of the experimenters dropped a pile of books not far from passers-by (men) in conditions both of quiet and of loud noise (which came from a motor mower with its "muffler" removed); in some of the tests he had a plaster cast on one arm.[26] During the noise he was helped by 10% of passers-by compared with 20% when it was quiet, and while wearing the plaster cast by only 15% in the noise but 80% in the quiet conditions. Though various interpretations are possible, this finding would be consistent with the effect of noise in narrowing attention.

References

1 Burns W. *Noise and man.* 2nd ed. London: John Murray, 1973.
2 Burns W, Robinson D. *Hearing and noise in industry.* London: HMSO, 1970.
3 Robinson DW, Burns W. Audiometry in industry. *Br Med J* 1978;ii:706.
4 Department of Employment. *Code of practice for reducing the exposure of employed persons to noise.* London: HMSO, 1972.
5 US Environmental Protection Agency. *Information on levels of environmental noise requisite to protect public and welfare with an adequate margin of safety.* Washington, DC: EPA, 1974.
6 Noise Advisory Council. *Hearing hazards and recreation.* London: HMSO, 1977.
7 Bickerdike J, Gregory A. *An evaluation of hearing damage risk to attenders at discotheques.* Leeds: School of Constructional Studies, Leeds Polytechnic, 1979 (with Noise Advisory Council memorandum, June 1980).
8 Hood JD, Poole JP, Freedman L. The influence of eye colour upon temporary threshold shift. *Audiology* 1976;**15**:449-64.
9 Carter NL. Eye colour and susceptibility to noise-induced permanent threshold shift. *Audiology* 1980;**19**:86-93.
10 Rosen S, Bergman M, Plester D, El-Mofty A, Satti MH. Presbycusis study of a relatively noise-free population in the Sudan. *Ann Otol Rhinol Laryngol* 1962;**71**:727-43.
11 Kell RL, Pearson JCG, Taylor W. Hearing thresholds in an island population in North Scotland. *Int Audiol* 1970;**9**:334-49.
12 Beales PH. *Noise, hearing and deafness.* London: Michael Joseph, 1965.
13 Beales P, Hood JD, Knight JJ, Hinchcliffe R, Fisch L. *Hearing* 1969: 41-3; 110-1; 132-3; 238; 239-44 (separate articles).
14 Elliott CD. What does "noisy" mean? *New Society* 1971;**52**:910-2.
15 Tarnapolsky A, Morton-Williams J. *Aircraft noise and prevalence of psychiatric disorders.* London: Social and Community Planning Research, 1980.
16 Committee on the Problem of Noise. *Noise: final report.* Cmnd 2056. London: HMSO, 1963. (Wilson Report.)
17 Bastenier H, Klosterkoetter W, Large JB. *Environment and the quality of life. Damage and annoyance caused by noise.* EUR 5398e. Brussels: Commission of the European Communities, 1975.
18 Large JB. Methods of assessing community response to environmental noise. *R Soc Health J* 1977;**97**:147-52.
19 Broadbent D. Noise in relation to annoyance, performance, and mental health. *J Am Soc Acoustics* (in press).
20 Office of Population Censuses and Surveys, Social Survey Division. *Second survey of aircraft noise annoyance around London (Heathrow) Airport.* London: HMSO, 1971.
21 Harland DG. A survey of noise and traffic nuisance at homes in England. *Proc Inst Acoustics* 1977 (meeting 12);1-6.
22 Borsky PN. Sleep interference and annoyance by aircraft noise. *Sound and Vibration* December 1976:18-21.
23 Shepherd M. Pollution, noise, and mental health. *Lancet* 1975;i:322-4.
24 Tarnapolsky A, Jenkins L, Watkins G, Hand DJ. Prospects for research into the effects of environmental noise on health: the case of mental health. In: *Proceedings of the Inter-Research-Council Seminar on Noise Pollution.* University of Southampton (in press).
25 Jenkins LM, Tarnapolsky A, Hand DJ, Barker SM. Comparison of three studies of aircraft noise and psychiatric hospital admissions conducted in the same area. *Psychol Med* 1979;**9**:681-93.
26 Broadbent D. Human performance in noise. In: Harris C, ed. *Handbook of noise control.* 2nd edn. New York: McGraw-Hill, 1978: ch 17, 1-19.
27 Bull AJ, *et al.* Effects of noise and intolerance of ambiguity upon attraction for similar and dissimilar others. *J Soc Psychol* 1972;**88**:151-2.
28 Mathews KE, jun, Canon LK. Environmental noise as a determinant of helping behaviour. *J Pers Soc Psych* 1979;**32**:571-7.

What dose of thiamine should be used in treating delirium tremens?

In view of the risks of more serious developments a dose of 25-100 mg of thiamine daily in divided doses should be given for three days, after which the dose may be halved. In cases of gastrointestinal disturbance the vitamin should be given intramuscularly or intravenously.

Goodman LS, Gilman A, eds. *The pharmacological basis of medical practice.* 5th ed. London: Baillière Tindall, 1975.
Wade A, ed. *Martindale: the extra pharmacopoeia.* 27th ed. London: Pharmaceutical Press, 1977.

Is the best treatment of warts masterly inactivity? Does not treatment compromise the body's natural defence against these virus infections?

Generalisations can sweep too far. One has to accept that all warts are not the same; and, while it is perfectly reasonable to allow inconspicuous and symptom-free warts to clear without treatment, this process is often slow and would not be suitable for, say, a single painful plantar wart in a marathon runner, genital warts in a promiscuous person, or a wart on the face of an actress. More active intervention is needed for these. Our knowledge of the body's natural defence against warts is still incomplete.[1] Perhaps the immunological response to wart antigens is less under vigorous treatment, but this does not amount to "compromising the body's natural defence," and is not a sufficient reason for withholding such treatment if required on clinical grounds.

1 Anonymous. Throwing off warts. *Br Med J* 1978;iii:821.