Pollution and People

Noise and health: public and private responsibility

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Disturbance of sleep is probably the most widespread source of distress caused by noise. Intuitively it appears to be harmful—at the least impairing wellbeing—but both the extent and the effects of the sleep disturbance are difficult to study scientifically. Laboratory experiments create artificial conditions and the findings are not necessarily applicable to real life; while people's subjective reports about their sleep are notoriously unreliable and may reflect their daytime response to noise—and objective investigations in their homes cannot be carried out on a large scale. A project is, however, under way in which French workers (see below) will collaborate with a team at the Southampton Institute of Sound and Vibration Research, monitoring people whose response to noise has been studied in their homes in a laboratory under similar conditions. Meanwhile we may ponder on extensive data from research of varying quality.

Noise and sleep

Some 20% of the population appear to have sleep disturbances that are unrelated to noise, according to a Greater London survey,[1] though noise may make their problems worse; in an American study, however, under 10% of those who lived about 19 km (12 miles) from the John F Kennedy Airport, New York, reported sleep disturbance, compared with 60% at 1·6 km from the airport.[2] With high levels of traffic noise one study suggested that half the good sleepers were disturbed by noise.[1] Peak noise levels of 60 dB(A)*—for instance, from passing traffic—or an ambient level of 50 dB(A) may considerably extend the time taken to fall asleep.[3,4] The threshold for awakening varies according to the person and the stage of sleep, but violently fluctuating noise is most disturbing, and an arousal threshold 10 dB(A) higher than the background level has been suggested on the basis of some experiments.[3] Changes in stage of sleep without awakening have turned out to be significantly correlated with lorry and train noise[4]; and the threshold for such objectively measured effects on sleep has been found to be 40-50 dB(A).[3] Thus some impairment of sleep by noise may be more widespread than social surveys based on self-reporting would suggest.

Sleep studies carried out in people's own bedrooms, recently reported from France, have provided objective information on the effects of motorway noise in real-life conditions; miniaturised equipment recorded the electroencephalogram (EEG), eye movements, muscular activity, and heart rhythm with a remote reading system, while the noise inside the bedroom was recorded continuously.[5] After the opening of the motorway, with noise levels inside the bedroom of 40 ± 3 dB(A) L_{eq} and peaks of only 55 ± 5 dB(A), people took longer to fall asleep and had on average 16 minutes less deep sleep (stages 3 and 4), so that the young-to-middle-aged group became more like a 50-60-year-old group in their depth of sleep. Rapid-eye-movement (REM) or dreaming sleep was also reduced, with no adaptation after five years.[5] Changing the position of the bedroom (or insulating the windows) reduced the noise by an average of 10 dB(A) L_{eq} and extended the duration of sleep.

Measuring the sound level of a pneumatic drill during the Darlington "quiet town experiment."

Since deep and REM sleep are believed to be physiologically and psychologically important such impairment of sleep may well be damaging. People living in very noisy houses did worse in psychological tests, notably one measuring the so-called unprepared simple reaction time (which depends on arousal), after noisy nights than when their bedrooms were fitted with double glazing; this reduced the noise level by about 10 dB(A) to an average of 41 dB(A) L_{eq}.[6] In a laboratory experiment using recordings of jet flyovers, noisy nights (which were interspersed with quiet nights) were followed the next morning by poorer performance in a reaction time test incorporating a memory component, with an electroencephalographic (EEG) pattern suggesting drowsiness.[7] Though the reliability of the test may possibly be questioned, the result is interesting in that the subjects had not necessarily been awakened by the "flyovers"—some indeed could not remember any during the

*See box in first article (15 November, p 1325) for note on noise units.

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DAPHNE GLOAG, MA, staff editor

night; the noises were, however, accompanied by EEG changes characteristic of activation—a total of three minutes of jet noise producing 45 minutes of EEG change in the course of the night.

Thus research supports the Wilson Committee's recommendation of noise levels at night, inside bedrooms, not exceeding 35 dB(A) for more than 10% of the time (30 dB(A) in country areas).[8] Similarly, the US Environmental Protection Agency recommends a maximum of 35 dB(A) averaged over the night.[9] Sleepers may nevertheless be disturbed by the occasional noise that is loud relative to the background (table), which may come from people inside or outside the building if not from road or other traffic; in the Darlington quiet town experiment (see box) nearly as many people in the sample survey were disturbed by other people (notably those leaving pubs) as by traffic.[10]

Some sound level measurements in bedrooms (London)

(recorded with CEL-175 Precision Integrating Sound Level Meter by courtesy of Computer Engineering Ltd)

	dB(A)	
Bedsitter facing side road, 9–10 pm:	*Window open*	
Low background noise level	27	
Average noise level	36 L_{eq}	
Plumbing noises	58 L_{max}	
Doors banging	58–65 ,,	
Footsteps overhead	51 ,,	
Cars passing	46–57 ,,	
	Window	
Flat away from road, midnight:	*open*	*closed*
Low background noise level	30	27
Average noise level	32	27 L_{eq}
Distant traffic, etc	40	36 L_{max}
Doors banging, next flat and downstairs	50–51 L_{max}	

For hospital wards an ambient level of 40 dB(A) has been recommended, with 50-55 dB(A) for intermittent noises depending on their number—but lower peak levels if the background is around 30 dB(A).[11] The US Environmental Protection Agency has recommended 35 dB L_{eq} at night and 45 dB by day.[9] The main problem is how to limit the nearby noises creating the peak levels.

Other effects on health

"Sonic boom—can jet noise kill?" was one of the headlines that followed news of a much-publicised study of mortality in relation to noise near Los Angeles International Airport; the incidence of deaths due to stroke, cardiovascular diseases, and cirrhosis was reported to be particularly raised. A reanalysis of the data, however, has since shown the "experimental" and control areas to have rates for cardiovascular and cerebrovascular disease nearly identical with each other and with Los Angeles County,[12] though the dispute continues.[13]

Nevertheless, there have been other such findings,[14 15] including a report of above-average rates of cardiovascular disease in men exposed to aircraft noise near Schipol Airport in the Netherlands.[16] Many studies, both epidemiological and experimental, have suggested a link between noise and diseases that include stroke, cardiovascular disease, hypertension, and peptic ulcer or gastritis—and, in the case of animal studies, effects on the immune system and the development of tumours.[14–16] A report from Japan, moreover, suggested an effect of aircraft noise on fetal development.[16] But populations and groups studied epidemiologically may not be adequately matched; while conclusions based on extrapolations from work in animals and from laboratory experiments in man are not necessarily valid. Thus, although noise can be shown experimentally to produce changes in circulation, skin resistance, muscles, and many other systems,[3] there is no firm evidence on long-term effects in man.

Nevertheless, a recent study is interesting in showing that recordings of industrial noise can cause significant increases in total peripheral resistance and diastolic blood pressure that last several minutes longer than the noise.[16a] In animals repetition of such noise-induced increases in blood pressure may lead to permanent hypertension, and indeed there are reports of higher blood pressures and higher incidences of hypertension in workers with long exposure to noise than in other workers.[16a] The idea that noise as a form of stress should have prolonged effects in some cases, produced by the autonomic and endocrine systems, is plausible. We particularly need to know what chronic effects noise might have in combination with other stresses or medical factors and in people who become least habituated to it.

The quiet town experiment

A "quiet town experiment" was recommended by the Noise Advisory Council and Darlington was chosen as a "typical" town, the project lasting from 1976 to 1978.[10] Though noise abatement zones and better traffic management were introduced, together with vehicle noise testing and stricter enforcement of regulations, the chief focus was educational. There was extensive press and radio coverage; leaflets, etc, were circulated and exhibitions, lectures, and school projects organised; and free advice on noise problems was given to industry and the public. The main object was not so much to create a quiet town as to make people more aware of noise. This seems to have been achieved to some extent, though the limited funds and some loss of credibility due to the somewhat misleading "Quiet town" slogan, say the organisers, did restrict the project's achievements.

The future

Fifteen per cent of the population of the OECD countries (that is, over 100 million people) are thought to be exposed to an average outdoor daytime noise level above 65 dB(A) L_{eq}, and over half to more than 55 dB(A) (Conclusions of the Organisation for Economic Co-operation and Development's Conference on Noise Abatement, 1980). These proportions are expected to increase, yet even at 55 dB(A) over 20% of people are "highly annoyed" (see Large[16] and figure in last article, p 1326).

Some countries—and WHO[14]—think that 55 dB(A) L_{eq} should be the long-term goal; the US Environmental Protection Agency, for example, recommends 55 dB L_{eq} by day and 45 dB at night.[9] The conference, however, proposed 60-65 dB(A) (day) and 50-55 dB(A) (night) as minimum objectives, with energetic measures for reducing noise at source (especially from motor vehicles) and for better planning as regards land use, traffic management, etc, as well as more use of noise barriers and soundproofing. Noise limits—carrying fines if exceeded—are already specified for different types of vehicle (for Britain see Noise Advisory Council)[17]; these are lenient for new models since the technology for producing quieter vehicles already exists. The OECD recommends reducing the noise emission level of motor vehicles by 5-10 dB(A), to come into effect during 1985-90 so that a quieter environment will be achieved by the year 2000. The reduction should mean that only 3-5% of the population will be exposed to noise over 65 dB(A) L_{eq}. The newer jet aircraft are less noisy than their predecessors; but more attention, says the OECD, could be given to flight paths, flying times, etc, and to the soundproofing of houses. It urges economic incentives in the form of levies and

tax relief to encourage noise abatement measures, including quiet installations, vehicles, etc; the taxes could finance better soundproofing and compensation schemes—though the feasibility of such strategies has yet to be proved.

No radical improvement will come unless noise is taken into account right from the start in all types of planning and manufacture[18]: remedial measures, taken possibly as an afterthought, tend to be less effective or not fully carried through. For example, grants for sound insulation are available[19] but many people exposed to disturbing noise do not qualify; and in the Heathrow scheme few even applied.[20] Planning for quietness will not always cost more, but an additional 1% on the price of motor vehicles, for example, per decibel saved has been estimated[21]—so the support of the community will be needed.

Houses and flats are a particularly important issue since they need to protect against indoor and outdoor noise made by other people, especially at night,[10] however low the "public" noise of an area. Though more people may hear traffic and aircraft than neighbours, the latter are the chief source of "bother."[22] Here the peaks rather than the average noise level are the important measure, especially as they are so disruptive to sleep, and my small series of measurements (table) illustrate the potentially disturbing nature of ordinary noises. The "meaningful" and preventable nature of such noise may also make it disproportionately disturbing. For indoor noise, existing knowledge is adequate to achieve buildings with good sound attenuation, at least of airborne sounds; but a survey of party walls and floors showed that under half met the performance standards specified in the Building Regulations.[23] In London, moreover, these regulations do not even apply. A recent survey, however, showed that nearly half the occupants of houses meeting or exceeding the Building Regulations' requirements heard noise from their neighbours (F J Langdon, personal communication). With good insulation, impact rather than airborne noise becomes important, and this needs to be eliminated by improving the layouts of adjoining dwellings, fitting doors that close quietly, and so on.

The Control of Pollution Act 1974 (see box) gives local authorities powers to prevent and deal with noise,[17] and nearly all authorities now have staff working on noise problems—generally by day only, though a few have "party squads."[24] The largest group of complaints, according to one survey, referred to noise created by neighbours[25]; but this may not be amenable to legal remedy—especially the banging doors, revving engines, and shouting that are so disturbing at night. Here the chief need is for people to become more responsible about the noise they make themselves—a task for education and publicity. Perhaps the best result of the Darlington experiment, despite all the limitations recognised by the organisers, was that a quarter of those interviewed afterwards claimed that they made less noise themselves.[10] I liked the words of one child[26]: ". . . I opened the door and I saw a dragon banging on the floor and I said to him, 'What is your name?' 'Monster Noise. Can I live with you?' 'No you cannot. . . .' And big tears thundered down his face and a big pool of water fell to the floor."

Noise and the law[17]

1—Complaints to local authority The environmental health department first attempts to resolve problems by informal discussions and if these fail serves noise abatement notices on those concerned. If these are ignored there may be summary proceedings in a magistrates' court or even High Court injunctions. The defendants can plead that the "best practicable means" have been used to limit noise: this recognises that there are technical and other limitations to the reduction of noise.

2—Complaints direct to magistrates An individual may also complain direct to a magistrates' court without going through the local authority.

3—Civil actions An action for noise nuisance can be taken at common law—often at great expense—on the grounds that the nuisance substantially affects health, comfort, or convenience (the "best practicable means" defence is not available).

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References

1 Langdon FJ, Buller IB. Road traffic noise and disturbance to sleep. *J Sound Vibration* 1977;**50**:13-28.

2 Borsky PN. Sleep interference and annoyance by aircraft noise. *Sound and Vibration* 1976 December:18-21.

3 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.

4 Vernet M. Effect of train noise on sleep for people living in homes bordering the railway line. *J Sound Vibration* 1979;**66**:483-92.

5 Vallet M. Psychophysiological effects of exposure to aircraft or road traffic noise. *Proceedings of the Institute of Acoustics* 1979 (meeting 20); **3**:1-4.

6 Wilkinson RT, Campbell KC, Roberts LD. The effect of noise at night upon performance during the day. In: *Noise as a public health problem* (Freiberg conference). Rockville, Marland: American Speech, Language and Hearing Association (in press).

7 LeVere TE, Bartus RT, Hart FD. Electroencephalographic and behavioural effects of nocturnally occurring jet aircraft sounds. *Aerospace Medicine* 1972;**43**:384-9.

8 Committee on the Problem of Noise. *Noise: final report.* Cmnd 2056. London: HMSO, 1963. (Wilson Report.)

9 US Environmental Protection Agency. *Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety.* Washington, DC: FPA, 1974.

10 Jupp VR, Landon L. *People and noise in Darlington.* Newcastle upon Tyne Polytechnic, 1978.

11 Walker JG. Noise in hospitals. In: May DN, ed. *Handbook of noise assessment.* New York: Van Nostrand Reinhold, 1978.

12 Frerichs RR, Beeman BL, Coulson AH. Los Angeles airport noise and mortality—faulty analysis and public policy. *Am J Public Health* 1980;**70**:357-62.

13 Meecham WC, Shaw N. Comments on "Los Angeles Airport noise and mortality—faulty analysis and public policy"; Frerichs RR, Coulson AH. Frerichs *et al* respond. *Am J Public Health* 1980;**70**:543-4.

14 United Nations Environmental Programme and World Health Organisation. *Environmental health criteria 12. Noise.* Geneva: WHO, 1980.

15 Workshop on Medical Effects of Environmental Noise. *J Sound Vibration* 1978;**59**:59-142.

16 Large JB. Methods of assessing community response to environmental noise. *R Soc Health J* 1977;**97**:147-52.

16a Andrén L, Hansson L, Björkman M, Jonsson A. Noise as a contributory factor in the development of elevated arterial pressure. *Acta Med Scand* 1980;**207**:493-8.

17 Noise Advisory Council. *Bothered by noise? How the law can help you.* 2nd ed. London: NAC, 1976 (reprinting).

18 Taylor R. *Noise.* Harmondsworth: Penguin, 1970.

19 Department of the Environment, Welsh Office, and Central Office of Information. *Land Compensation—your rights explained: 5. Insulation against traffic noise.* 3rd ed. London: HMSO, 1980.

20 Office of Population Censuses and Surveys, Social Survey Division. *Second survey of aircraft noise annoyance around London (Heathrow) Airport.* London: HMSO, 1971.

21 Murray I. Too many decibels for comfort. *The Times* 1980 May 5.

22 Langdon FJ, Buller IB. Party wall insulation and noise from neighbours. *J Sound Vibration* 1977;**55**:495-507.

23 Sewell EC, Scholes WE. *Sound insulation performance between dwellings built in the early 1970s.* Garston: Building Research Establishment, 1978.

24 Dryden SM. *The Times* 1980 August 2:13.

25 Mulholland KA. Local environmental health officers and noise. *Environmental Health* 1979;**87**:74-6.

26 Doyle L. In: *Children on noise.* Darlington (undated):1.