PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A
MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

A Study of Problems of Noise in Offices

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A study of problems of noise in offices

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Introduction

The work now being carried out by the Building Research Station on the problems of work in offices has arisen from a series of more general studies of the office environment (Langdon 1959, 1963, 1965; Collins & Langdon 1960; Langdon & Keighley 1964) in the course of which the attitudes of office workers toward the social, functional and physical features of their surroundings were related to measurements of the main physical aspects, such as space, lighting, heating, noise and so on. The principal aim of these inquiries was to reveal particular problems associated with the type of office being studied, and to assess physical standards as related to comfort and satisfaction, particularly when these could not be defined operationally.

While it might be agreed that studies of this kind are useful for exploring the general, over-all environment, it might also be agreed that the complex interplay of many physical and social factors, together with large individual differences, would severely limit their utility when applied to a single aspect such as noise nuisance. Granted that there is some substance in this objection, such difficulties are not insuperable. It is not necessary to assume that individuals behave like measuring instruments, accurately assessing the physical environment by a scale. Experience has shown that individual scale ratings can be treated statistically to yield a realistic community assessment of any single environmental aspect, purely in terms of whether it is satisfactory or not. Apart from this, however, a powerful argument in favour of statistical surveys related to physical measurement is that standards of comfort are best determined by reference to the working situation in an actual environment. One of the recurring outcomes of these earlier studies was to stress the need for further work on noise nuisance in offices, for dissatisfaction in this particular was universal, noise being consistently rated one of the worst features in offices (Langdon 1966). It appeared that the actual practice of noise control was falling short of contemporary requirements.

The survey method

The method of statistical survey was again applied to an exploratory study of the factors governing people's response to noise (Keighley 1966). A sample of twelve large offices was selected, each office room accommodating more than fifty persons, ranging from ordinary clerical offices to machine rooms. All personnel were invited to complete a questionnaire, giving information about themselves and their jobs, rating the general features of the office, and making a detailed appraisal of the niose climate by means of scales of noisiness and degree of acceptability. In each of the rooms, samples of noise were recorded and subsequently analysed, these recordings being supplemented by spot measurements at different points obtained with a sound level meter using the 'A' weighting network.

The mean scale scores for 'noisiness' and 'satisfaction' or 'acceptability' were calculated and expressed as a percentage value for each room. When compared with the physical measurements they were found to be significantly related to the average level measured in dB(A), though only when this was supplemented by a further physical variable. The second physical measure represented an attempt to quantify individual impulse sounds rising significantly above the modal noise level.

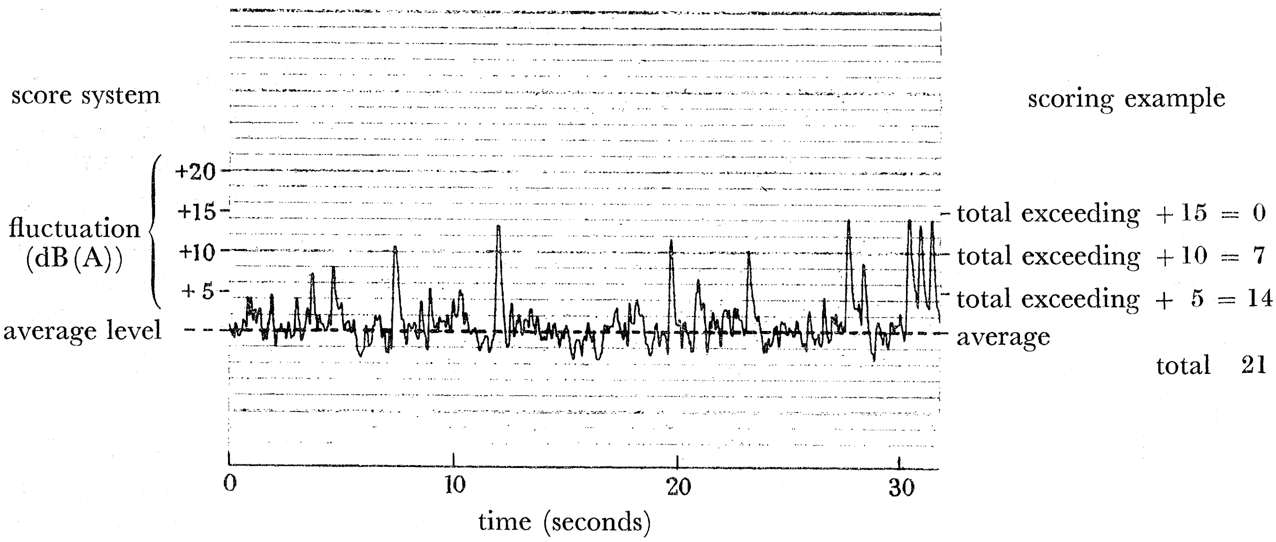

FIGURE 1. Illustration of procedure for obtaining transient peak index from level recorder trace of office noise.

TRANSIENT PEAK INDEX

In any office, a variety of bangs and clatters are heard above the relatively steady background of noise and these are visible as distinct peaks on the recorder trace (figure 1). To derive a quantitative measure, peaks exceeding the modal level by more than 5 dB were counted and the total expressed as average rate of occurrence per minute. This measure, termed for convenience the transient peak index, was also found to be highly correlated with the rating of acceptability at any given noise level, and it therefore appeared that the dissatisfaction generated by noise was governed both by average noise level and the rate of peaks rising significantly above this level.

It is possible to plot the relation between the subjective rating and these two physical measures. However, as this results in a three-dimensional display, sections have been drawn to yield contours of equal acceptability and these are shown in figure 2. It will be seen that for any given noise level, acceptability falls as the value of the peak index rises, though not uniformly, while for a given value of peak index, acceptability declines with a rise in average level.

Nevertheless, the initial sample of twelve offices is comparatively small so that not too much weight could be attached to the results of this preliminary investigation. Similar data was therefore collected from a further twenty-three office rooms and while this material was being analysed some laboratory experiments were undertaken to supplement and check the findings of the initial survey.

In these experiments three groups of four subjects were presented with nine samples of noise, comprising three values of peak index for each of three average levels, in random order of presentation. Thus each of the two physical variables were controlled independently of the other. The subjects were asked to rate what they thought would be the degree of acceptability for each noise condition in a large office, using a seven-point semantic differential scale.

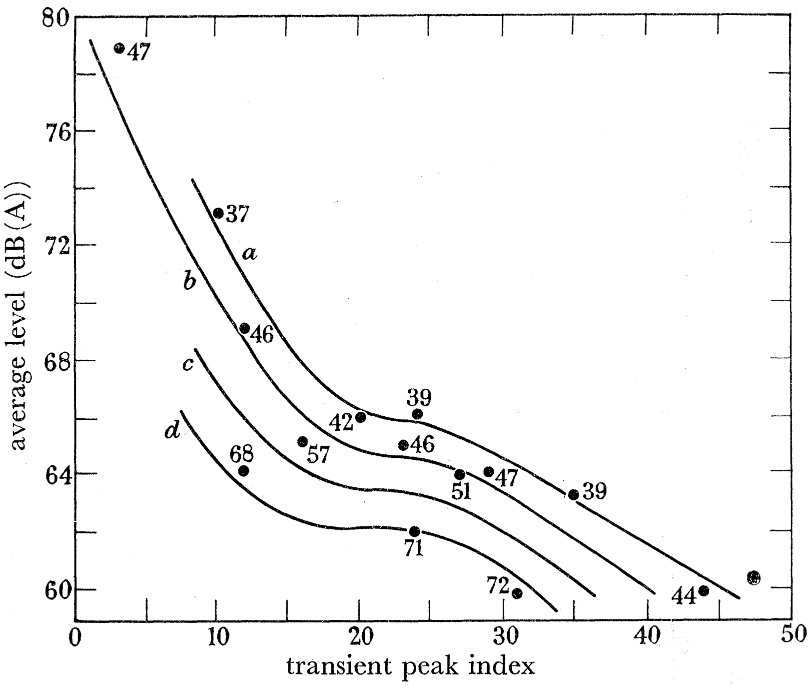

FIGURE 2. Contours of equal acceptability fitted to data for offices.

curve	a	b	c	d
scale value	4	50	60	70
dissatisfied	1 in 2	1 in 3	1 in 7	1 in 10

The results of this experiment confirmed conclusively the findings of the preliminary survey, although the absolute values of acceptability scores were other than those obtained in the survey. In figure 3 these scores are plotted against values of peak index for each of the three average noise levels and it is interesting to observe that acceptability declines with a rise in peak index with no change in the average level. To complete the exercise, predicted values of acceptability derived from a regression equation were plotted against the actual values obtained and these are shown in figure 4.

With a total sample from the initial and the validation survey of thirty-five offices the relation between each of the two physical measures and the ratings of acceptability was calculated and the results are shown in figures 5 and 6. These regressions were found to be significant at the 1 % level of confidence, though a certain amount of scatter is still present. This is common in psycho-physical surveys and will be discussed later.

Figure 7 illustrates the contours of equal acceptability derived from these relationships, corresponding to those already shown in figure 2 for the original twelve offices and it will be seen that they are now somewhat smoother and cover a wider range, largely as a result

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of better sampling. From the standpoint of practical noise control, the main area of interest lies between the 50 and 70 % acceptability contours since these apply where between one person in four and one in ten will be definitely dissatisfied. Finally, figure 8 shows actual scores of acceptability plotted against predicted scores.

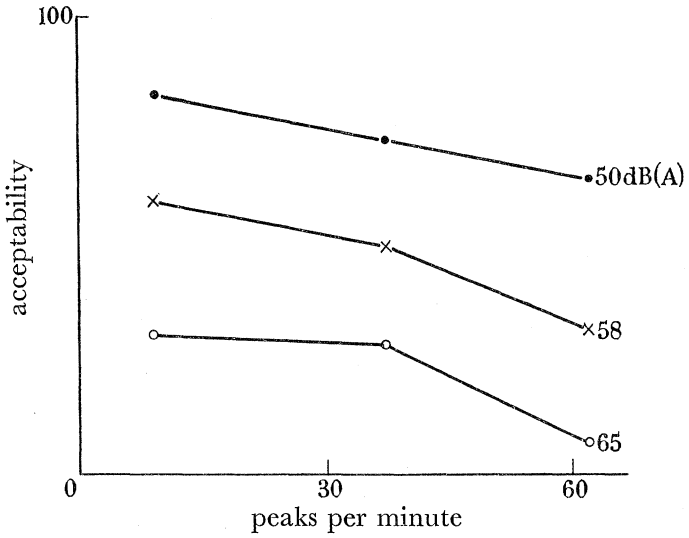

FIGURE 3

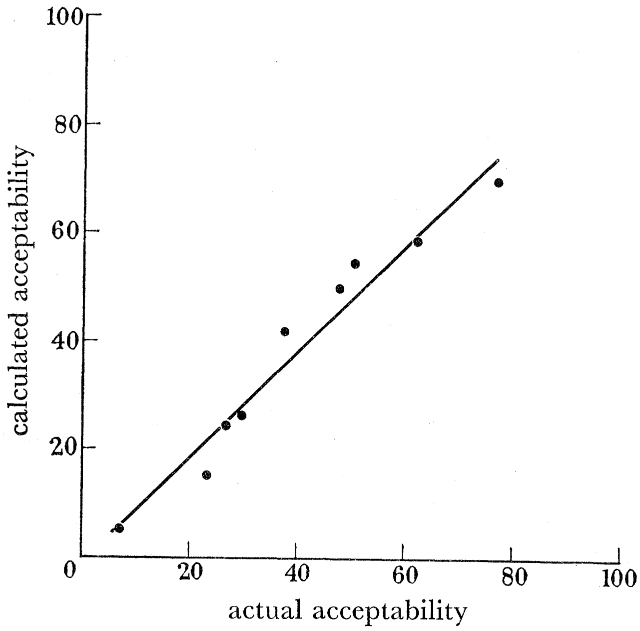

FIGURE 4

It will be noted that some scatter is present, though the relationship is significant at the 1 % level of confidence. There are a number of sources of residual variance which are at present being investigated. Two of the most important are individual differences between office workers, and the sampling in noise measurement. As regards the first of these, numerous studies of noise nuisance (McKennell 1963; McKennell & Hunt 1966) have shown that there are wide disparities in noise tolerance between one person and another. A filter test to take account of this has been devised and is incorporated in the present

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study, though it has not yet been applied to the calculation of the regression equations shown here. It is known, however, that the effect of separating the office population by this means is to reduce considerably the scatter in acceptability ratings.

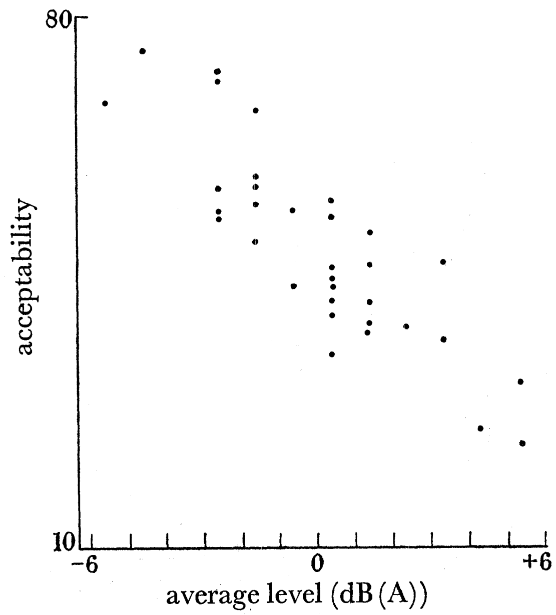

FIGURE 5. Acceptability related to average level with peak index held constant.

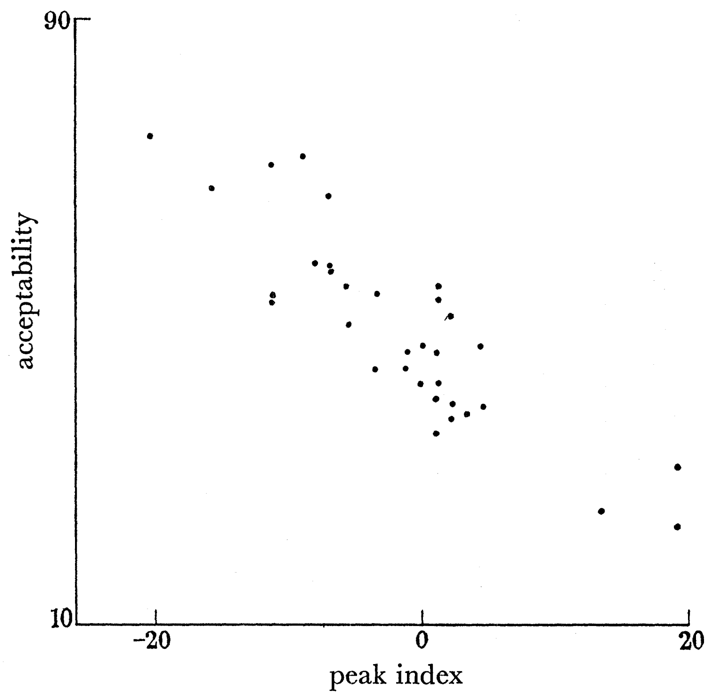

FIGURE 6. Acceptability related to peak index with average level held constant.

The second source of scatter is the imperfect representativeness of physical measurements. In many offices, noise levels vary not only from day to day, but over long periods according to the flow of work. The precise situation cannot always be ascertained by inquiry, since one is invariably informed that the current period is exceptionally quiet and

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that the noise is usually far worse. It may therefore be anticipated that in some cases measurements obtained in the course of a week do not represent the total long-term situation, to which the subjective data are assumed to relate. Nevertheless, despite these

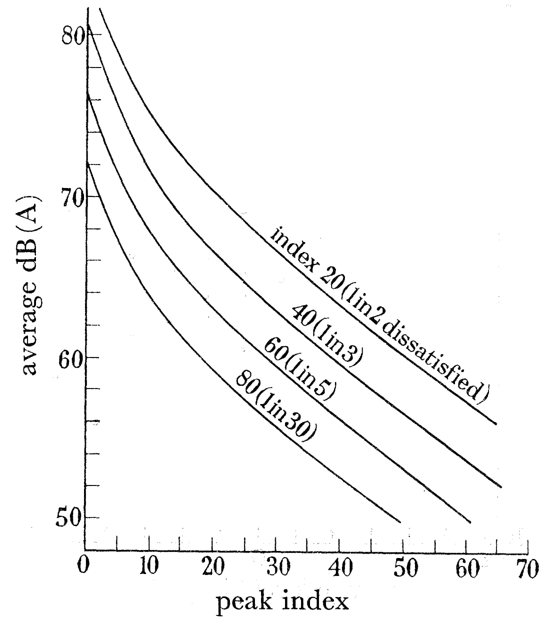

FIGURE 7. Contours of equal acceptability.

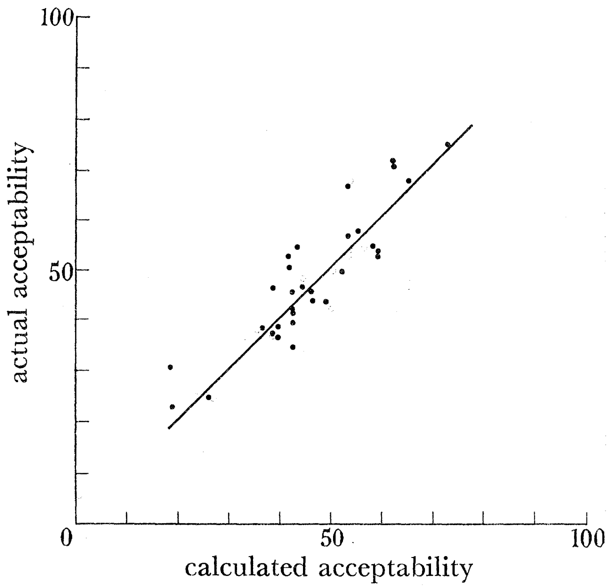

FIGURE 8

sources of error, a reasonably good prediction of the probable degree of acceptability of the noise climate can be made for the great majority of offices, irrespective of the type of activity and the functions they perform. It is of course desirable to apply the system outlined here to smaller rooms having only a few persons, though it will be appreciated that in these circumstances individual differences become more important so that predictions can only be applied in a very general way.

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Conclusion

It is not the purpose of this paper to discuss practical measures of noise control, though since it must be conceded that transient noises are a major source of disturbance, it follows that an immediate focus of attention is the nuisance caused by sources of impact noise. It is evident that care taken to obviate unnecessary noise by suitable design of furniture and equipment offers a relatively simple and economical contribution to noise control.

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