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HUMAN RESPONSE TO INDUSTRIAL AND TRANSPORTATION NOISE

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1. INTRODUCTION

This paper constitutes the first account of two parallel but independent pilot studies on human response to noise, being conducted by WS Atkins Noise and Vibration under the direction of BRE, acting for the Department of the Environment. They are differentiated by their focus on two different classes of noise source, viz. industry and transportation.

The measurement and prediction processes for each source are in practice necessarily different. It is also easier to define a soluble research problem if one confines attention to one source. However such focusing on a specific source leaves unasked basic questions relating to the way the public respond to noise sources when they are heard together. It can also lead to a continuing divergence in the way we predict public response to noise from different sources. (Is background noise level of primary importance for the prediction of public response to noise from industry, but of no relevance in the context of aircraft noise?).

The strategies adopted in the two pilot studies have a common starting point. That starting point is the general public, and their concerns, and that is the main subject of this paper.

2. OBJECTIVES

Both studies arose out of the Report of the Noise Review Working Party (the Batho Report).

For industrial noise the most frequently used criterion is set out in BS 4142:1990. It is widely accepted that this Standard is not as well supported by field data on what levels of noise occupants consider acceptable as we would wish. In nuisance assessment, Environmental Health Officers frequently find themselves in a situation in which they use a method intended for the prediction of the likelihood of complaints, after they are certain that complaints have occurred. Within the development planning process, the same method is used, not because it was derived for that context, but because of the lack of a widely accepted alternative. The current research programme on industrial noise is intended to provide a more informed basis for the preparation of planning guidance relating to new dwellings near existing industrial noise sources. It is also anticipated that the information
will also assist in any future revision of BS 4142 for the purposes of nuisance assessment.

Transportation noise has generated a considerably greater volume of relevant research literature. There is a plethora of criteria for different transportation sources, resulting from the source-specific context in which that literature has mainly developed. Studies have tended to concentrate on higher levels of exposure to a particular source, both because of a need to ensure that the sample in a particular study is not subject to variance from other sources, and because of an interest in establishing the level at which the mitigation measure of insulation becomes appropriate.

There have been some brave attempts to integrate the results from studies on two or more source types. The concept of the Noise Pollution Level was an early example, and more recently the Mitchell Committee had such a requirement built into their terms of reference. But the difficulties inherent in such re-analyses are considerable, and the results sometimes sterile. (The classic example is the published debate between Schultz and Kryter, which ended with more acrimony than illumination.)

In fact there has been relatively little research on the way in which the general public react to transportation noise sources experienced in combination. There are competing models of human response to multiple transportation sources in the literature, whose simplicity ranges from a simple worst-case model, in which the public response to noises in combination is equal to their greatest response to each of the noise sources rated separately. The use of L_{Aeq} as a universal measure inherently assumes an energy summation model in the determination of response. An independent effects model would assume that there is a summation of responses to the separate noise sources, but the functional relationships between physical noise parameters and subjective responses could vary between noise sources. Other models assume that there is an inhibition as well as a summation component, and that the response to one source is potentially inhibited by the concurrent presence of a second or third source. (To revert to industrial noise, the assessment level within BS 4142 suggests that the response to industrial noise response is exclusively determined by the inhibitory or subtractive effect of the background noise, and that there is no summation component relating to the absolute magnitude of either source.)

Therefore, the current program seeks to address the problems of moderate exposure levels, and thereby the potential benefits of mitigation measures other than insulation, and of human response to multiple sources.

3. DEPTH INTERVIEWS

The remainder of the paper contains an account of one phase of each of the two pilot studies, concerned with elucidating the language and concerns of the general public with regard to noise from the two source types. It is a truism, though one of which we occasionally loose sight, that for noise "man is the measure", and any meter reading, no matter how sophisticated, has only

a secondary validity. To that I would add that "people determine parameters" and that in deciding what we should attempt to measure, we should seek to understand and reflect the concerns of the public.

A social survey using quwstionnaires, and paralleled by physical measurements, is a basic toolused in the development and validation of methods for predicting the public response tonoise. But a questionnaire is necessarily and properly a highly structured device, which is used to collect answers from the public to questions which have been asked by the researcher. Those questions, again properly, are incluenced by questions that have been asked in previous stuides, for in this way the body of knowledge can be coherently increased. However there is a danger that our questions become solely determined by previous studies, and fail to reflect comprehensively the concerns of the public.

In an attempt to address this problem both pilot studies have commenced with a programme of depth (or unstructured) interviews. Residents with homes near industrial or near transportation noise sources, have been asked to talk about noise from industry, or from road, rail and air traffic. The interviewer confined his or her contribution to encouragement, showing of interest, and to non-directive support. Thus the respondent, not the interviewer, decided the content of the interview. The interviews were tape recorded and verbatim transcripts prepared. 33 interviews were obtained on industrial noise, and 34 on transportation noise.

4. CONTENT ANALYSES OF PUBLIC RESPONSE

The depth interviews allow the respondents to determine the agenda as well as the content of their responses. Such a free-form approach results in a considerable volume of material which is at once relatively unbiased in content, rich in anecdote, but weakly structured. Before it can be summarised it has to be classified.

Each interview is broken down into a number of clauses, possibly overlapping. (Content which is of no relevance to noise and/or its effects is ignored.) Thus the statement "this screeching noise woke me up on Sunday", contains three different propositions, about a screeching sound quality, about being woken up, and about Sunday. Once the clauses, or mentions, have been identified and unpacked, they can be assembled into classes and categories. Like any other nominal measure the categories should be mutually exclusive and completely exhaustive. If it is difficult to decide in which of two categories a clause should be placed the first criteria is breached, and if a residual category labelled 'unclassified' holds more than a few clauses the latter criterion has been breached.

In practice the process is achieved by starting with a small sample of interviews, and large

categories. The categories can be subdivided as closely related clauses accumulate, and are tested and further refined by succeeding interview analyses. New categories can be added as similar clauses accumulate in the residual category. Given the richness of the English language, and the imprecision with which it is sometimes used, the verbatim transcripts require a degree of interpretation, but in general there is little difficulty in classifying most clauses.

The categories initially used for the analysis of interviews on industrial noise were:

- Time
- Noise Characteristics
- Noise Sources
- Responses
- Situational variables
- Unclassified.

Each main category became subdivided, thus the 'time' category was developed by distinguishing between clauses relating to the time of day, clauses which distinguished between a weekday or a Sunday, and clauses which made a distinction between an HRT effect during Summer or Winter. A complete list of the final categories used in the analysis is given in Table I. It will be noted that only 31 out of a total of 940 clauses could not be placed in one of the categories.

Table I gives in column 2 the absolute number of clauses across all respondents, and also in column 3 the percentage of respondents who generated one or more clauses within each category.

The categories are not explicitly defined, it is usually clear from the words and their context into which category they should be assigned. However, given that they are fuzzy sets, and that no attempt was made to assemble of representative sample of respondents, the absolute values should be treated as indicators of the salience of a category and not as a precise measure. Thus we can be confidant that diurnal aspects of industrial noise have a greater salience than weekly or annual aspects, but not that weekly aspects are of more significance than annual aspects.

The category cited most frequently is that which contains references to specific sources of noise, (fans, crushers etc.). The second most frequently used category is that of evaluative comments - including of course neutral comments such as "I don't mind the noise", as well as negative responses. The frequency with which noises are described in terms of the time of day is high, as is the percentage of respondents who think this worthy of mention (70%). This is in many cases linked to comments on the effects of noise on sleep - or its prevention. Disturbance of sleep is mentioned more frequently and by more respondents than disturbance of any other activity. Not one respondent mentioned any effect of industrial noise on conversation, or on

the use of the telephone.

It is interesting to compare the topics mentioned by respondents with the variables within BS 4142. It will be recalled that BS 4142 incorporates as variables the relative "loudness" of the industrial source, its tonality, impulsiveness and attention gaining unpredictability, and the relative loudness of the background noise.

Tonality and impulsiveness have both been classified within sound quality. There were 25 mentions of tonal character from 42% of respondents, and 14 mentions of impulsiveness from 33% of respondents. Loudness was mentioned by 47% of respondents, as was predictability. Only background noise level received little comment, with 8 mentions and that from only 18% of respondents. This, of course, does not prove that background noise level is irrelevant in the determination of response to industrial noise. However, it does indicate that the general public are not generally aware of it having any great significance.

The classification exercise for transportation noise was undertaken after that for industrial noise. It became immediately apparent that the content was sufficiently similar as to justify the initial use of the same categories, with relatively minor adaptations, particularly for disturbance to other activities. The results of the analysis are set out in Table 2.

There are some remarkable similarities between the two sets of interviews. Thus, for example, 70% of respondents cited diurnal aspects of industrial noise, as did 74% for transportation noise. The percentages mentioning sleep were also similar, at 42% and 50% respectively.

There are also significant differences. Thus, conversation and interference with conversation is mentioned by 44% of respondents talking about transportation noise, but by none of those talking about noise from industry. Annual variations (50%) and effects within the garden (65%) are of greater salience for transportation noise than for industrial noise (33% and 33% respectively). That complaint activity in relation to industrial noise is mentioned by more respondents than in relation to transportation noise perhaps reflects the anonymity of road traffic noise sources (61% as against 29% of respondents).

5. THE PROFESSIONAL CONTENTS

A small sample of 8 acoustic consultants and Environmental Health Officers had been approached before the content analysis of the depth interviews was undertaken. They were asked to list the aspects of industrial noise which they considered were of significance in determining the response of the public to industrial noise. The intention had been to utilize the aspects listed as an initial coding frame for content analysis. In fact such an initial coding frame from an alien source proved unnecessary. However, the results from this aspect listing

exercise are in themselves of interest, as they suggest that we may be subject to professional acculturation. Table 3 shows the number of professionals who included particular topics within their lists.

Of the seven most frequently cited aspects, all seven are reflected in an assessment using BS 4142. Tonality, impulsiveness, background noise level and loudness are all explicitly included in the Standard. Predictability is covered within the Standard in the phrase "irregular enough to attract attention". Time of day and duration are reflected in the Standard by the reference time intervals of 1 hour and 5 minutes for day and night use respectively. It could be said that the present Standard therefore responds to the consensus of informed opinion. Or, it might be argued that by frequent application of the Standard we convince ourselves of the significance of the variables included within it.

6. CONCLUSION

It would be inappropriate to draw conclusions on human response to industrial and transportation noise from the information included within this paper. The research continues, guided and informed by the analyses described above. Questionnaires have been prepared which respond to these analyses, both in terms of content and vocabulary. Also included in those questionnaires are scaling techniques which have become established within the body of literature. Their parallel development for industrial and transportation noise should enable comparisons, not only of responses to road, rail and aircraft noise, but also between the two classes of source. Further papers will deal with the questionnaires and the measurement regimes.

This paper has been approved for publication by the Department of the Environment but the contents are the responsibility of the author, and should not be taken to constitute Departmental opinion or policy.

HUMAN RESPONSE TO INDUSTRIAL AND TRANSPORTATION NOISE

TABLE 1: INDUSTRIAL NOISE

CATEGORY	No. OF CLAUSES	% RESPONDENTS
TIME		
DAILY	113	70
WEEKLY	36	36
SEASONALLY	29	33
NOISE CHARACTERISTICS		
DURATION		
CONTINUOUS	18	36
> YEAR	5	13
> MONTH	4	9
> WEEK	6	18
> DAY	2	6
> HOUR	2	6
> MINUTE	4	12
INTERMITTENT	13	21
PREDICTABILITY	16	30
LOUDNESS	54	55
BACKGROUND LEVEL	8	18
NOISE CHANGES OVER TIME	26	45
SOUND QUALITY	55	64
VIBRATION	12	18
NOISE SOURCES	174	85
PERSONAL FACTORS		
PERIOD OF RESIDENCE	10	24
SENSITIVITY	10	12
RESPONSES		
GENERAL EVALUATIVE MENTIONS	115	85
DISTURBANCE TO ACTIVITIES		
SLEEP	32	42
CONCENTRATION	7	9
CONVERSATION	0	0
TELEPHONE	0	0
RADIO/TV	10	13
OTHER ACTIVITIES	0	0
BEHAVIOUR RESPONSES	6	6
COMPLAINTS		
COMPLAINT ACTIVITY	40	61
INDUSTRIAL RESPONSE	27	24
SITUATIONAL CHARACTERISTICS		
DISTANCE TO NOISE	16	30
RELATIVE POSITION OF BEDROOM	14	27
GARDEN	18	33
INSULATION	28	48
SCREENING	16	30
METEOROLOGICAL	11	21
UNCLASSIFIED	31	61

HUMAN RESPONSE TO INDUSTRIAL AND TRANSPORTATION NOISE

TABLE 2: TRANSPORTATION NOISE

CATEGORY	No. OF CLAUSES	% RESPONDENTS
TIME		
DAILY	71	74
WEEKLY	8	18
SEASONALLY	47	50
NOISE CHARACTERISTICS		
DURATION		
CONTINUOUS	31	41
>YEAR	2	6
>MONTH	3	9
>WEEK	1	3
>DAY	4	12
>HOUR	5	12
>MINUTE	2	6
INTERMITTENT	55	65
PREDICTABILITY	31	47
LOUDNESS	25	47
BACKGROUND LEVEL	8	15
NOISE CHANGES OVER TIME	39	50
SOUND QUALITY	46	59
VIBRATION	12	18
NOISE SOURCES	392	94
PERSONAL FACTORS		
PERIOD OF RESIDENCE	24	30
SENSITIVITY	11	29
RESPONSE		
GENERAL EVALUATIVE MENTIONS	397	94
DISTURBANCE TO ACTIVITIES		
SLEEP	34	50
CONCENTRATION	2	6
CONVERSATION	32	44
TELEPHONE	3	6
RADIO/TV	15	29
OTHER ACTIVITIES	5	12
BEHAVIOUR RESPONSES	2	3
COMPLAINTS		
COMPLAINT ACTIVITY	21	29
TRANSPORTATION RESPONSE	31	44
SITUATIONAL CHARACTERISTICS		
DISTANCE TO NOISE	69	65
RELATIVE POSITION OF BEDROOM	13	24
GARDEN	42	65
INSULATION	62	79
SCREENING	17	24
METEOROLOGICAL	33	47
UNCLASSIFIED	54	53

TABLE 3: PROFESSIONAL LISTINGS

ASPECT	NUMBER OF RESPONDENTS
DAILY	8
TONALITY	8
IMPULSIVENESS	7
BACKGROUND NOISE	6
LOUDNESS	5
PREDICTABILITY	5
DURATION	5
CHARACTER OF AREA	4
ANNUAL	4
NOISE SOURCES	4
ALL OTHER TOPICS	3 OR LESS