SUBJECTIVE RESPONSE TO CHANGES IN ROAD TRAFFIC NOISE

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The effect of changed traffic noise conditions was investigated in a sample of 469 residents at eight sites in the South of England. Measurement of subjective response to noise under conditions of steady state noise exposure was used to predict response to changes in noise level. Changes in dissatisfaction with traffic noise following an increase or decrease in noise exposure were found to be considerably greater than predicted from the steady state data. A follow-up survey at three of the original sites showed no adaptation of the initially large response after a period of 17-22 months. A repeat survey of five sites originally studied by the Transport and Road Research Laboratory showed evidence of only partial adaptation after 7-9 years.

INTRODUCTION

Studies of subjective response to traffic noise have mostly been concerned with the effects of steady-state noise conditions [e.g. 1,2,3,4]. Fewer investigators have attempted to assess noise control measures such as by-passes or barriers, but re-analysis of two such studies [5] indicated that response to changes in noise exposure cannot be predicted by a simple application of rules derived from studies of approximately constant noise conditions.

This conclusion has now been confirmed by research designed specifically to test it. In our previous study [6] 469 residents at 8 sites in the South of England, who were exposed to increases or decreases in traffic noise, were interviewed 1-7 months before the changes and 2-3 months after. Changes in dissatisfaction with traffic noise were significantly greater than predicted on the basis of the 'before' (steady state) data: where a decrease in noise exposure occurs, the decrease in dissatisfaction with traffic noise is greater than predicted from findings in steady state conditions. Similarly, where an increase in noise exposure occurs, the increase in dissatisfaction is greater than predicted.

A study of a single site [7] found a similar result, although differences in method make direct comparison difficult. A similar effect has been found for aircraft noise [8], but the earlier re-analysis [5] indicates a strong possibility that, for traffic noise, barriers may have an effect in the opposite direction (i.e. that reductions in exposure are significantly undervalued).

These findings are likely to be of importance in informing policy on environmental assessment, particularly since it is clear that the magnitude of the effects observed is sufficiently large for their practical significance not to be in doubt: the effect of change is equivalent to at least 10dB(A)

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difference in L_{10}. Application of the results would, however, depend on their time-scale: whether the effects are persistent over time.

It is improbable, in fact, that the effects are temporary: Weinstein [9] concluded from an extensive review of the literature that there was no evidence of adaptation to noise from road traffic or other modes of transport, and reported a study specifically intended to investigate the existence of adaptation. This study showed that there was no adaptation, at least over a period from 4 to 16 months after the opening of a new major road.

However, the assumption that the effects of change are not subject to reduction over time requires specific verification. Continuation of the investigation of sites previously investigated by ourselves or by the Transport and Road Research Laboratory [see 5] provided the means to do this. The study concerns medium- and long-term adaptation and it is convenient to report these two phases separately.

MEDIUM-TERM ADAPTATION

Research Method

We repeated the 'after' phase of our previous investigation [6], with the number of sites reduced to three: Coggeshall, Ampthill, and Northgate, Beccles. These were all sites at which a noise reduction had taken place. Three further such sites were not used (one had undergone a negligible decrease in noise, and two had been used in a third phase of the previous study. Two sites which had undergone an increase in noise exposure were also not used (one had been subject to further increases in noise, the other would have yielded too small a sample).

Acoustic and psychological surveys were conducted 17-22 months after the change and followed the same methodology as the first 'after' study, with the addition to the questionnaire of items concerned directly with changes in traffic nuisance. Repeat interviews were achieved with 90 of the 126 original respondents. The measure of subjective response was, as described in detail in [6], the mean of two ratings given during the same interview, and has a substantially higher reliability than individual ratings (see also [10]).

Results and Discussion

Changes in L_{10} between the first and second 'after' study were less than 1dB(A) and can be regarded as negligible. Table 1 shows that there was no significant change in dissatisfaction, interference due to noise, loudness ratings or sensitivity to noise, thus supporting the hypothesis that there is no adaptation. Only general opinion of the area showed a significant change, an improvement (i.e. the opposite direction to that predicted on the basis of adaptation). This may be explained if residents take longer to assess non-noise benefits of the reduction in traffic (e.g. vibration damage, danger) than the noise benefit.

It may be concluded that the excess benefit of a reduction in noise exposure observed shortly after the change is not reduced by adaptation over a period of 17-22 months. This reduces the likelihood that the initial effect is merely one of contrast over time.

Table 1: Changes in subjective response between the 1st and 2nd 'after' phases.

RESPONSE	1st Phase	2nd Phase	Difference	t p<
Dissatisfaction	3.18	3.03	-0.15	N.S.
Interference	2.34	2.14	-0.20	N.S.
Loudness	3.69	3.78	0.09	N.S.
Sensitivity	4.38	4.21	-0.17	N.S.
Opinion of the area	3.02	2.20	-0.82	3.93 0.001

N.S. = Not significant

LONG TERM ADAPTATION

Research Method

This investigation was, as far as possible, a repeat of the 'after' phase of the original studies carried out by the Transport and Road Research Laboratory (TRRL). Identification of the original respondents was not possible from the data available. Of the original nine sites, only five were eligible for further study in terms of the criteria of sample size and the absence of large changes in traffic flow since the original investigation. Table 2 lists these sites.

Table 2: The survey sites.

SITE NUMBER	SITE	YEAR OF CHANGE
1	Boughton (Kent)	1976
2	Bridge (Kent)	1976
3	Mere (Wiltshire)	1976
4	Lewes (E Sussex)	1978
5	E Grinstead (W Sussex)	1978

Parallel acoustic and psychological surveys were carried out at each of these sites, together with classified traffic counts. An interview was carried out with one adult per household. This was not restricted to those resident at the time of the original noise reduction, which allowed for a direct test of the hypothesis that those who had experienced the reduction in noise should be less dissatisfied with the present noise level, which is the same for both groups. The questionnaire used was based on the one used by TRRL in the original study.

In the case of only one site, East Grinstead, was it possible to make a direct comparison with the original noise measurements and here the change in measured L_{10} amounted to -0.1dB(A). Table 3 gives traffic flow data for all five sites in the two relevant phases of the studies, and the change in L_{10} calculated [11] from the flow data. The mean calculated change over the five sites is 0.04dB(A).

Table 3: Traffic data and calculated change in L_{10} dB(A), by site.

	ORIGINAL SURVEY		REPEAT SURVEY		CALCULATED CHANGE IN L10
SITE	Total	%HV	Total	%HV	
1	2160	13	2748	9	0.2
2	1390	13	2880	6	1.6
3	3255	8	3792	9	0.9
4	7300	13	8130	5	-1.2
5	9280	11	10350	4	-1.3

Total = Total traffic flow per 16 hour day (06.00-22.00)
%HV = Percentage heavy vehicles

Results and Discussion

Table 4 shows mean bother scores from the repeat survey, for those resident at the time of the change in noise and those not. All differences between these two groups are positive (i.e. newer residents are more bothered than original residents), and the mean difference of 0.26 is statistically significant ($t=3.1$, $n=223,207$). If the equivalence established in a previous study [5] is accepted (22dB(A) per scale interval), then the observed difference is equivalent to the two groups living at sites differing in noise exposure by 5.7dB(A) L_{10}. This is a lower figure than that observed as the excess produced immediately after change [6]. The two groups do not differ in self-rated sensitivity (mean ratings 3.76 and 3.73) or in general opinion of the area (mean ratings 1.88 and 1.78).

Table 4: Mean bother scores (repeat survey) for those resident at the time of the change in noise exposure and those not.

SITE	ORIGINAL RESIDENTS	NEW RESIDENTS	DIFFERENCE
1	1.69	1.89	0.20
2	1.81	2.15	0.34
3	1.61	1.89	0.28
4	1.55	1.94	0.39
5	2.13	2.16	0.03

Table 5 shows a comparison of the bother scores of the original TRRL sample and those in the repeat survey who were resident at the time of the original survey. Ideally this comparison would have involved current residents only if they were interviewed in the original 'after' study. However, too few respondents recalled being interviewed in the original study for this to be possible.

Table 5: Comparison of bother scores for original TRRL survey and the repeat survey (original residents only).

SITE	ORIGINAL	REPEAT	DIFFERENCE	N	t	p<
1	1.38	1.69	0.31	62	2.88	0.001
2	1.25	1.81	0.56	37	4.13	0.001
3	0.84	1.61	0.77	61	7.29	0.001
4	2.30	1.55	-0.75	31	-3.89	0.001
5	1.88	2.13	0.25	16		N.S.

N.S. = Not significant

It can be seen from Table 5 that 4 out of 5 comparisons result in significant differences. Of these, 3 are in the direction of increased bother (i.e. a reduction in the excess benefit resulting from change). The mean difference in 0.23 scale units. Perhaps coincidentally, this difference added to the mean difference between resident groups (0.26) is 0.49, which is similar to the difference between predicted and actual results in the TRRL study (0.53) [5].

The three sites at which there was a significant long-term increase in dissatisfaction were all villages with relatively little locally-generated traffic, which experienced the change in noise some 9 years before our study. The two sites at which there was no increase in dissatisfaction were medium-sized towns with rather more locally-generated traffic, which experienced the change in noise only 7 years before our study. These differences may be important, but cannot adequately be evaluated using our data. It may be that there is partial adaptation after 9 years at the first type of site, but no adaptation after up to seven years at the second type of site.

DISCUSSION

It is clear that the excess effects in change in noise exposure are real and substantial. The evidence presented here relates to the occurrence of a step-change in noise exposure and there is no evidence that similar effects would be seen under circumstances of a more gradual change. It is also now clear that this is a relatively long-term phenomenon, since it has shown no diminution up to approximately two years after the change. Over a period of 7-9 years, it would appear that perhaps 40% of the effect has disappeared, but that there is still a significant difference in response between those who experienced the change and those who have moved in since it occurred.

The results are quite clear, the interpretation is more difficult. We [12] have recently examined a model which offered an opportunity to explain both steady state and change effects on the same basis, but this model did not account for our results. Two alternative models have recently been proposed by Brown et al [7]. Both models depend on the idea that response to noise consists of two components: the "effects of noise" (on the respondent), and the respondent's subjective assessment of those effects as expressed in the scale rating.

Model 1 predicts that, the higher the noise level, the lower will be the scale rating given to a particular level of noise effects. This model would predict in our study an effect in the opposite direction to the one actually found: the change in dissatisfaction should be less than predicted from the change in noise exposure. In Model 2, adaptation level is proposed to vary such that the higher the chronic noise exposure, the lower are the effects of noise at any point in time. This model is contradicted by our finding that there is no adaptation.

It could be argued that respondents do not accurately report their response to noise in the 'after' condition, as a consequence of their beliefs about what response is expected or their attitude to the change in noise. This would raise problems since the same account could be applied to response in the 'before' condition, which forms the basis of policy. If fact, it is difficult to explain our results in terms of beliefs or attitudes, for the following reasons.

First, there are difficulties in applying such explanations in a consistent way to both increases and decreases in noise exposure. It is particularly difficult to account for the absence of a difference in the noise-response relationship in the 'before' condition between sites at which an increase in noise was anticipated and sites at which a decrease was anticipated [6]. Expectations and attitudes should be very different between these two conditions.

Second, the excess change in subjective response is approximately constant, regardless of the magnitude of the change in noise exposure, the starting and final level of exposure and the characteristics and history of the site. It would be necessary, for example, to assume the same pattern of changes in attitudes/beliefs to apply to (a) a country town divided by a busy single carriageway trunk road with an high proportion of articulated lorries which could not easily pass in the narrow centre of the town and (b) a village on a road adequate for two large vehicles to pass, by-passed as a consequence of the need to by-pass the neighbouring town, and losing trade as a result.

Third, we would have to assume that attitudes and expectations have not changed 17-22 months after a change in noise exposure, and change only slowly over a period of 9 years or more.

Since there appears to be no adequate existing model which would account for our results, we propose a new model, based on the Brown et al models [7]. Their term 'noise effects' may obscure a complex set of inter-relationships. The simplest next step is to divide 'noise effects' into two, and we suggest 'objective effects of noise' and 'subjective assessment of effects'. Objective effects would include for example preventing sleep or concentration or causing headaches. Subjective assessment would be the respondent's assessment of the sum of these effects, plus experience of noise as an aversive stimulus irrespective of the behaviours with which it interferes. Scale ratings would then represent the respondent's attempt to assign numbers to subjective experience of noise.

This model was reflected in our questionnaire design, and we therefore have some capacity for testing it. In the literature, the most important measure of subjective assessment is dissatisfaction (or a similar scale). The most important measure of objective effects of noise is rating of interference with behaviour. Both types of rating were included in the questionnaire. The relation between interference (I) and dissatisfaction (D) is variable, the same level of interference resulting in higher dissatisfaction before a decrease in noise.

In the 'before' condition, $D_B = I+1.8$

In the 'after' condition, $D_A = 1.1I+0.7 \Rightarrow D_B-D_A = -0.1I+1.1$

It can be seen that this difference is approximately constant across the range of interference ratings, and the effect is therefore similar in this respect to the effect of change on dissatisfaction. Thus, there is evidence of a change in the relationship between objective effects and subjective assessment of those effects: a decrease (increase) in noise exposure appears to result in a more positive (negative) subjective assessment of objective effects of noise.

We have a single hypothesis which explains both this effect and the excess effect of changes in noise exposure on dissatisfaction. We propose that, when noise undergoes a step change, there is a rapid change in sensitisation to the direct aversive component of subjective response. This change would have to bring the final level of sensitisation to a level higher than would be expected under steady state conditions when noise exposure increases, and lower than expected when noise exposure decreases.

The finding that there is no adaptation can be explained in terms of "coping behaviour". At any level of noise exposure, there is likely to be adaptive coping with the objective effects of noise. Coping behaviour is a form of adaptation excluded by Weinstein's definition [9], and one which is likely to occur: change of the physical properties of the dwelling (e.g. double glazing) and/or change of behaviour (e.g. closing windows). It is excluded from the definition because it does not imply any change in responsiveness.

Coping behaviour is likely to be partly retained when noise exposure decreases with a step change. Desensitisation following decreased noise exposure might be retained over an extended period because of the retained coping. A constant excess effect on dissatisfaction would result if sensitisation were higher at higher noise levels, but more coping behaviour were abandoned in a decrease from a higher noise level (for example if more extreme forms such as living in only half the house or never opening the windows were quickly abandoned). Lack of adaptation following an increase in noise exposure could be explained by continuing slow sensitisation and slow introduction of coping behaviour.

In summary then, there appears to be a composite effect. There is evidence for a variable relation between objective effects and subjective evaluation. We also need to propose a variable relation between (external) noise level and objective effects in the case of both decreased and increased noise exposure, due to coping behaviour. This account is part post-hoc, part based on an a priori model, and must be subjected to specific testing, but it provides an adequate account of minimal complexity. It also sheds light on the conflict between the intuitive assertion that adaptation does occur, and the scientific conclusion that adaptation does not occur. The answer may be that both intuition and science are correct, and that the conflict arises because our methods of measurement are confounded by the counteracting factors of coping and sensitisation.

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