RESPONSES TO A REDUCTION IN TRAFFIC NOISE EXPOSURE

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Current criteria for road traffic noise have been based on studies of community response (annoyance) measured under relatively steady-state conditions. The paper examines various mechanisms which may operate under such conditions to alter the annoyance of a group of people and which impinge on the validity of annoyance measures. A study of response to a reduction in noise level indicates a much larger reduction in annoyance than would be anticipated from responses under steady-state conditions.

INTRODUCTION: Field surveys of community response to environmental noise, particularly noise from transport sources, have appeared in the literature since the 1960s. The primary instrument used for measurement of community response to noise has generally been some scale of annoyance (or dissatisfaction) often in association with measures of the effect of noise on behaviour. Respondents' annoyance scores, either as individual scores or some aggregated measure of group response, have then been correlated with physical measures of noise exposure. Except where the effect of specific physical changes were to be monitored most surveys have been carried out under what could be described as "steady state" conditions, viz., no obvious change in the noise environment apart from that attributable to the annual growth in traffic, and a stable residential population with no unusual inward and outward migration rates. The existence of such steady-state conditions has not been reported explicitly in the various studies, but it seems reasonable to infer that study sites were selected with such conditions in mind.

Griffiths *et al* (1980) have commented that while it is possible in such studies to demonstrate statistical relationships between measures of exposure and measurements of such subjective reactions as annoyance and dissatisfaction, the fundamental requirements for the validity and reliability of the subjective measurement techniques have not been demonstrated. It is the purpose of this paper to pose some questions regarding the validity of the subjective measurement technique when it is applied under steady state conditions as defined above. In other words, do annoyance scores obtained from an exposed group in a steady-state situation really measure the effect of noise on that group? It is convenient here to postulate various mechanisms in a longitudinal model of the effect of noise on a group of people (say, all residents of the one roadway) which could influence subjective reaction to noise as measured at one slice in time.

CONCEPTUAL MODEL: The model postulated here makes no claim to comprehensiveness. It considers only three mechanisms: differential susceptibilities to noise annoyance between immigrant and emigrant populations, adaptation to noise, and repression of noise annoyance. Other mechanisms, such as change in community awareness, or expectations regarding the acoustic environment, could perhaps be included. However, it should be regarded as an initial attempt at providing a dynamic framework for existing conceptual models of subjective reaction to noise (e.g., Hede *et al* 1979) which are essentially static.

The first mechanism involves the normal turnover in population experienced in most residential areas. It is possible that outward migrants may include those people most affected by the noise and that inward migrants may include those who will be little affected. The latter requires an intending

immigrant to be aware of both the noise exposure at the site and the potential effect of that exposure. While this mechanism could clearly influence the annoyance scores measured from a group of respondents, it cannot be said to affect the validity of the measurements as the change in measured annoyance truly reflects a change in the effect of noise on this group. The results are applicable to the surveyed population at one point in time. However, such a mechanism, if active, would invalidate the application of these survey results to the assessment of the impact of an increased noise exposure on a different population.

A second mechanism which may influence subjective reaction to noise is *adaptation*. This term, which is preferred here to the more usual term *habituation* in order to clearly differentiate it from the next mechanism, refers to the postulated ability of a person to "get used to the noise". It implies that a person's subjective assessment of a new noise environment would become less adverse with continuing exposure. We have chosen to clearly define *adaptation* as an *accommodation to the noise without cost to the individual*. The existence of an adaptation mechanism is part of the folklore of noise. However, several field studies (e.g., Vallet *et al* 1978) found no evidence that habituation to noise had taken place, though these limited studies could not be regarded as conclusive. Taylor and Hall (1976) reported a positive correlation between length of residence and level of noise disturbance; support for the absence of adaptation and/or the presence of a migration mechanism. As in the case of migration, the presence of adaptation does not invalidate assessment of subjective reaction. Again, change in the measured annoyance reflects real change in the effect of noise.

The third mechanism we have termed *repression*. It is suggested that a person, subject to an adverse noise exposure which is relatively beyond his or her control, may actively exclude annoyance from conscious awareness, or at least attenuate the magnitude of subjective reactions to the noise. There is adequate evidence that many people exposed to high road traffic noise levels perceive futility in trying to achieve any mitigation of the noise (Brown, 1978), and Langdon in Alexandre *et al* (1975) comments, "... its victims experience difficulty in identifying individual offenders or locating responsible agencies, nor are they easily able to formulate schemes capable of giving immediate relief". For many people, relocation or expensive house insulation may not be real options. Whereas *adaptation* was defined as accommodation to the noise without cost, *repression* is defined as accommodation to the noise in the absence of any other course of action, and presumably cannot be accomplished without cost. It is suggested that this mechanism may produce a change in measured subjective reaction to noise, without any change having occurred in the real effect of the noise. In part, the following study was designed to explore this repression mechanism.

THE STUDY: In 1979 a residential street in Brisbane which had carried heavy traffic volumes for many years was relieved of through traffic by the opening of a freeway extension. Traffic volumes reduced from 20,000 veh./day to 3,000 vehicles/day. Residents living along the roadway experienced a major improvement in environmental quality including a large drop in noise levels. It was believed that this would be accompanied by a change in the residents' subjective reaction to the roadway noise, from high annoyance to lower annoyance.

Residents along this roadway will be referred to as the experimental group. Two control groups were also included in the study. These were residents along two roadways which were respectively matched to the before (high traffic volume) and after (low traffic volume) conditions on the

experimental roadway. Matching was based on traffic volumes, noise levels and physical characteristics such as roadway cross-section and housing type (see Table 1).

Surveys of residents on all three roadways were conducted between November 1980 and April 1981; a minimum of 15 months after the change had occurred on the experimental roadway. Interview surveys were completed with 60, 52 and 40 respondents on the experimental, before control and after control roadways respectively. Response rates were high on all roadways (85-90%) with the smaller after control sample resulting from a large number of non-contactables (three calls back were required). The questionnaire, developed specifically for the study, sought information on all effects associated with living in proximity to a roadway. Only one item is reported in this paper, viz., responses to the question, "To what extent does traffic noise annoy you here?". The scale presented to respondents was the seven-point semantically labelled scale used in Brown (1978) (see Fig. 1).

In addition to their assessment of the existing (low volume) conditions, the experimental group were asked, "To what extent did traffic noise annoy you *before* the freeway extension was completed?" The same seven-point scale was used in this retrospective assessment.

RESULTS AND DISCUSSION: The distribution of annoyance scores obtained from each group of respondents are shown in Figure 2.

Control Groups: Annoyance scores reported from the two control roadways were distributed over the whole scale, but with the expected result of the after control group (low volume) generally reporting low noise annoyance and the before control group high annoyance. The literature has tended to report the annoyance of a group either by median scores or the percentage of respondents scoring higher than some arbitrary break-point on the annoyance scale (e.g., respondents scoring at the 6th or 7th point on the scale defined as "highly annoyed"), and these statistics are shown for all groups in Fig. 2. In addition to the results from the control roadways, Fig. 2 shows noise annoyance distributions which were obtained in an earlier study (Brown, 1978) from sites somewhat similar to the control roadways. It can be seen that the distributions are generally supportive of those measured from the control groups, though on the low volume roadway, a higher proportion of respondents reported high annoyance.

Experimental Group: The noise annoyance distributions from the experimental group were markedly different. In the retrospective assessment of annoyance for conditions before the change, the experimental group reported very high annoyance, with more than 80% recording the highest point on the scale. No respondents recalled their annoyance as rating less than the mid-point on the scale. After the change, most of the group reported low annoyance, with only one respondent reporting annoyance higher than the mid-point of the scale.

If the noise annoyance distributions measured from the control roadway under steady-state conditions are regarded as typical - and there is little reason to presume otherwise, then members of the experimental groups, reported atypically high annoyance with conditions which existed before the change and atypically low annoyance with noise level conditions after the change. In other words, the people who had experienced a large reduction in noise levels outside their dwellings have reported a much larger improvement in acoustic amenity (i.e., reduction in noise annoyance) than would be anticipated from a simple comparison of annoyance distributions obtained under steady-state conditions. This difference is highlighted if conventional

measures of group annoyance are used. The median score for the group experiencing the change dropped from 6.9 to 1.9 (5 points of the 7 point annoyance scale) while the steady-state drop was only 4.6 to 2.9 (1.7 points). Similarly, the percentage of respondents in the experimental group who were highly annoyed dropped from 87% to 2%, compared to the steady-state change of 40% to 4%. Obviously some explanation of these differences is required.

The first and most obvious explanation is that respondents in the experimental group were not able to correctly recall how much they were annoyed before the change. However, two factors should be borne in mind when considering the magnitude of any memory distortion. The first is that memory is dependent, among other things, on the learning period and that some 80% of the experimental group had lived on the roadway for more than five years. The second is that memory distortion may be in the direction of dampened response (Campbell and Stanley, 1963).

An alternative explanation is that this difference may be evidence of the repression mechanism postulated above. If it is argued that people subject to "unavoidable" high levels of noise repress their annoyance, then the experimental group, relieved of the excessive noise exposure, were no longer in need of a defense mechanism, and were able to articulate the effect that the previous noise levels had had on them. By contrast, the before control group, surveyed under steady-state conditions, with no expectations of remission from high levels of noise may be more affected than is indicated by their self-reported annoyance.

If this is so, it has important ramifications for any study of the dose-response relationship for noise. Measures of group annoyance, particularly at higher levels of exposure, may be an attenuated measure of the true effect of noise on the group. A repression mechanism could contribute to the low correlations and the low gradients of the dose-response curve, generally reported from such studies.

CONCLUSIONS: This paper has suggested various mechanisms which may alter the annoyance of a group of people who are exposed to noise. The existence of a repression mechanism would cast doubt on the validity of measurements of subjective reaction to noise under steady-state conditions with important ramifications for the interpretation of past studies of dose-response relationships. The finding that people who have experienced an improvement in their acoustic environment report a much larger reduction in annoyance than expected, suggests such a mechanism. The finding should, however, be treated with some caution until the effect of memory distortion on this result is explored.

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TABLE I
NOISE LEVEL AND TRAFFIC DATA FOR THE EXPERIMENTAL, CONTROL AND SUPPLEMENTARY SITES (All roadways were two-lane, two-way roadways.)

Experimental Site		Control Sites		Supplementary Sites	
High Volume	Low Volume	High Volume	Low Volume	High Volume	Low Volume
<u>Traffic Volumes</u>					
24 hour	19864	2903	19776	2673	20460
(est. from 12hr)					3810
12 hour	14898	2177	14832	2005	16480
					2820
<u>% Heavy Vehicle Content</u>					
6.9		2	6.8	3.8	11
					3
<u>Distance from Centreline of Roadway to Dwelling Facade (m)</u>					
17		17	16	14	14
					20
<u>Noise Levels (dB(A))</u>					
<u>L₁₀ (12h)</u>					
(0700-1900)	74.3 ¹	64.5	75.1	65.2	78.0
					64.3
<u>L₁₀ (18h)</u>					
	n.a.	61.7	73.8	62.4	75.5
					63.0

1. Noise levels for all groups were measured except those for the experimental roadway before conditions. These were predicted using the U.K. Department of the Environment procedure using available 12-hour traffic data. All measurements, site selection, the questionnaire and social profile of the study groups are available in Kyle-Little (1981).

not at all	1	(Numerical values are not part of the scale, but are used for convenience to present the results of Figure 2.)
very little	2	
a small amount	3	
a fair amount	4	
quite a bit	5	
a lot	6	
a great deal	7	

FIGURE I : The Annoyance Scale

Figure 2: Distribution of noise annoyance scores for each group of respondents. Of the 60 people interviewed on the experimental roadway, annoyance scores are shown only for the 49 who had been in residence before the change.