A Comparison of the Annoyance Reduction Effects of Different Shielding Types

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Introduction

In view of the many expensive measures currently being taken to protect people from noise, the question which arises is whether the methods being used are as effective in reducing the impact of noise on people as they are in reducing the physical sound levels. This question is important since the methods used to date have assumed that physical measures of sound are reliable indicators of the effects of noise on people. The work done for this paper has provided an empirical test of that assumption, in the situation where some kind of barrier or shielding is installed between the highway and the residential area. This aspect is important to consider because transportation agencies are turning increasingly to the construction of barriers and buffers, as a method of reducing transportation noise.

It is not obvious what the effectiveness of a barrier is in reducing adverse impacts, as opposed to their acoustical effectiveness. It is possible that the acoustical effectiveness and the impact effectiveness are the same, so that the present assumption is correct, that acoustical measurements are good surrogates for noise impacts. However, two other possibilities are also evident. First the impact effectiveness may be less effective than the acoustical effectiveness, signifying that the residents living in an area where a barrier has been constructed may still be aware of the presence of the highway, and even the reduced noise levels may lead to more annoyance, complaints, and activity interference than one would expect from the sound level readings. On the other hand, impact effectiveness may be greater than acoustical effectiveness, such that the presence of the barrier has some kind of psychological effect, over and above its acoustical properties. For example, highway effects such as headlight glare, spray and dust may be mixed in with any response to road traffic noise, and therefore elimination of these will cause the adverse reaction to the noise to be less than would be expected from the sound levels. This question is important since the cost-effectiveness of shielding for noise must be expressed in terms of what it does for people, and not simply what it does for sound levels.

This paper investigates responses to road traffic noise in a number of residential areas which have some form of shielding between them and the highway. The impact effectiveness of the shielding is analyzed by comparing responses at each site with the responses to traffic noise at a second site, which experiences the same sound

level at the dwelling, but which is either unshielded from the road, or is shielded by a different material.

Data Used

The data for such an analysis was collected throughout the summers of 1975 and 1976 under projects sponsored by the Ontario Ministry of the Environment. Data pertaining to attitudes to noise, activities interfered with by noise, perceived health effects of noise, and actions taken due to noise were collected in a number of residential neighbourhood sites. Each site consisted of a single row of housing parallel to the roadway in question, and was affected by no major noise sources other than the roadway. A twenty-four hour record of the noise levels was also taken, subsequent to the interviewing.

On the basis of this noise level information, all of the sites from the data collection efforts were considered to find pairs of sites with as similar as possible sound level readings at the residences, and with different kinds or degrees of shielding between the housing and the road. The acoustical effectiveness of the barrier is not under investigation here, since the sound levels at the housing units are the same in each pair, but not the noise generated by the road. For example, the first pair out of the five that were identified is illustrated in Figure I. It compares the responses of people in the second row of housing along a major highway which has a daily traffic volume of more than 90,000 vehicles, with the responses of people living adjacent to an arterial street which carries less than 30,000 vehicles daily. Clearly the noise at the road edge is much higher in the first instance than in the second. The point is that the sound levels at the residence are the same for each pair of sites, as shown by the monitor readings (Table 1). The day-evening-night equivalent level, L_{DEN}, was used as the principal identifier of similar sites, but day, evening and night-time Leq are also shown to permit more detailed comparison.

For each pair of sites, a large number of variables from the household interviews were investigated to see if there were any significant differences between the two sites in the responses (Table 2). Two variables deal with people's overall attitude toward the noise in their neighbourhood. The first is whether or not the respondent volunteered that noise was something they disliked about their neighbourhood, and the second was their rating of the overall neighbourhood noise on a 9-point bipolar scale ranging from extremely agreeable to extremely disturbing. The remaining variables deal with responses to specific noise sources, which for this analysis have been limited to the main road in general and trucks in particular. For each of these sources, there are sets of variables dealing with attitudes, activity interference, actions taken, and perceived health effects. The attitudes were measured in three ways: first; by whether or not the person volunteered that the specific source was a noise he or she noticed. Secondly, by a rating for each person mentioning the noise source, on the ordinal nine-point bipolar scale. Lastly, by a rating for each

person disturbed by the noise source, on an interval level disturbance scale. Activity interruption is based on whether or not the respondent volunteered the information that any of the activities listed (Table 2) were interrupted by noise from each source. Information on actions taken was derived from a list read to the respondent (Table 2). Respondents were also asked if the specific noise source had any effect on their family's health, specifically those items shown (Table 2). Thus, in addition to the two variables on overall attitudes to noise, there are a total of 27 source-specific responses available for analysis.

Despite this large number of variables available for analysis, the method is quite straightforward. All we are examining is whether the response to the same noise level is different when different types of shielding or barriers are present. This comparison can be accomplished with several simple statistical tests: A chi-square test is used for the nominal variables, a Mann-Whitney test for the ordinal variables, and a T-test for the interval rating scale.

Results

The results of these tests proved to be quite informative (Table 3). In all five pairs of sites, there is a significant difference in attitude to the overall community noise. In two of the pairs, the difference is in the number volunteering noise as a problem; in the other three pairs the difference occurs on the rating of the community noise. Pair 1 indicates that a single row of housing is more effective in improving such attitudes than is a single row of trees providing a partial visual screen. Pair 2 indicates that several rows of housing are more effective subjectively than no shielding at all, while pair 3 suggests that no shielding at all is more effective than a solid concrete wall. The remaining 2 pairs suggest that a tree screen is more effective than no shielding at all. Consequently, if one is willing to postulate transitivity for such comparisons of effectiveness, the order of effectiveness of these types of shielding for improving attitudes toward the overall noise in a neighbourhood is as shown in Figure 2.

There is considerably less effect when one looks at variables referring directly to the main road traffic noise (Table 4). There is no significant difference in attitudes to the traffic noise in four of the five pairs, on any of the variables analyzed. Therefore, the figure shown previously refers only to the attitudes towards the overall community noise. When one considers the activities interfered with, there are significant differences at only two of the sites. Only one variable out of 8 action or 6 health effects shows up as significant, and this is only at a single site. By the general tendency of the sites, we may conclude that there is probably no meaningful difference in shielding types with respect to actions taken or the preceived health effects.

There are also no significant differences for any of the above variables in response to truck noise.

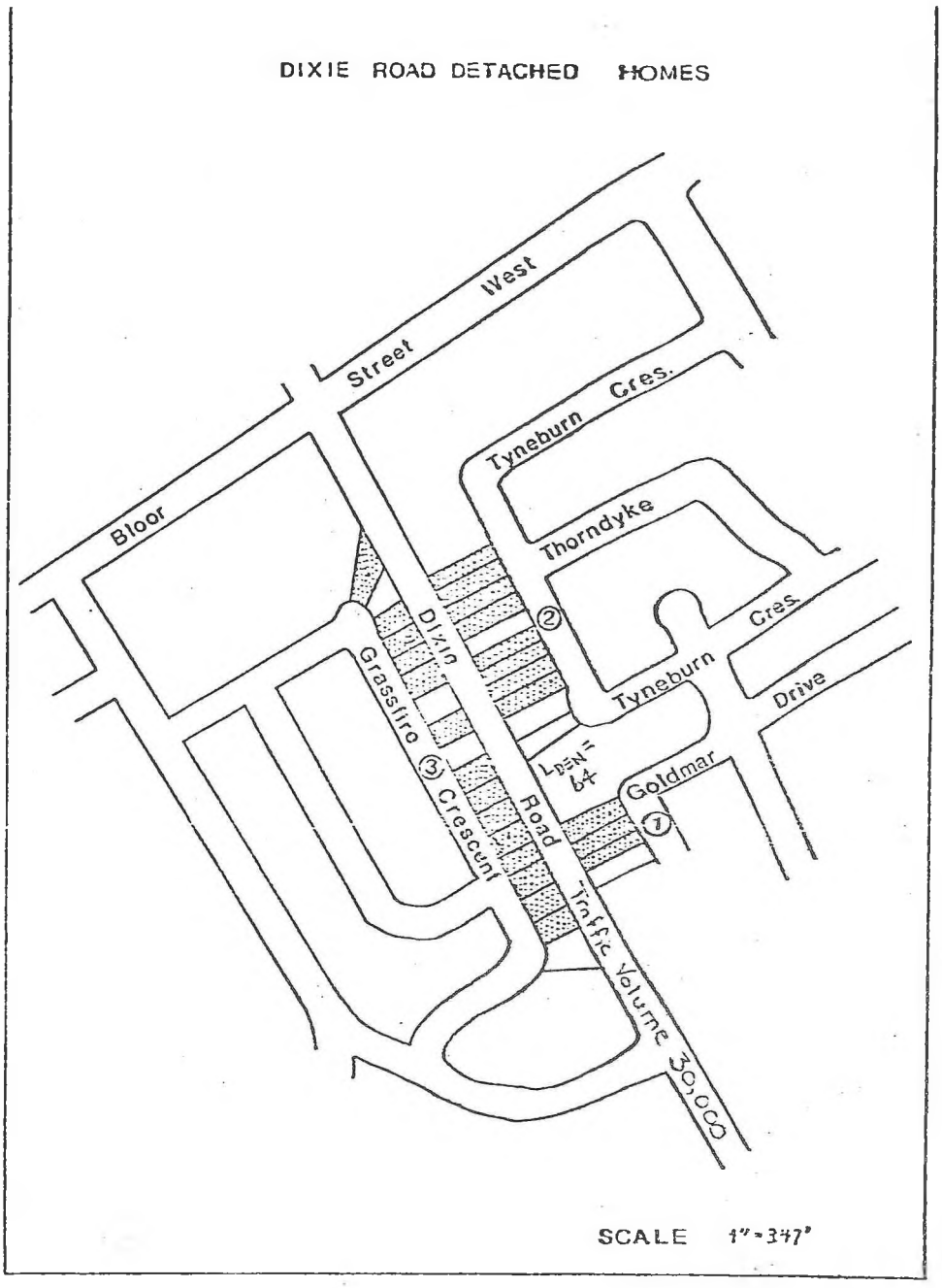
Conclusions

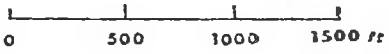
All forms of shielding investigated appear to be equally effective with respect to a large range of responses to road traffic noise. Therefore, the working assumption that sound level measurement is a reasonable surrogate for the measurement of road traffic noise impacts is supported. It may be assumed that any barrier which reduces sound levels will reduce impacts equally. However, this applies only to source-specific reactions. There does appear to be a significant difference in the effectiveness of different kinds of shielding with respect to the overall noise in their neighbourhoods.

One curiosity in the findings is that full visual shielding is on the one hand psychologically beneficial (in the case of a row of housing), and on the other hand psychologically detrimental (in the case of the concrete wall). We can only speculate about the reasons for this. It is generally accepted that noise causes adverse attitudinal reactions not simply as a result of its level, but also because of meanings associated with it. A concrete wall removes the sight of the road, but not all the characteristics associated with the traffic, of which one is reminded by the noise. A person living in such a situation is constantly reminded that they live next to a busy highway by that noise. A row of houses also constitutes an effective visual screen, but they also serve to put distance and other people between the resident and the highway. Therefore, the negative associations are more remote, and not necessarily a part of the neighbourhood in question.

Another question which is raised by this analysis is whether adding trees or other landscaping to an effective sound barrier improves attitudes in any way. A study directed to the effect of the appearance of barriers on attitude would seem useful, given the amount of money which has and will be spent on highway barriers. An acoustically effective barrier will clearly reduce the adverse effects of traffic noise. The question to be answered is whether an aesthetically pleasing barrier will improve general attitudes even more.

SITE PAIR 1


DIXIE ROAD DETACHED HOMES
Bloor
West
Street
Tyneburn Cres.
Thorndyke
Cres.
Tyneburn
Drive
Goldmar
Dixie
Grassfire
Crescent
Road
Traffic Volume 30,000
L_{DEN} = 64
SCALE 1" = 347'


0
500
1000
1500 ft

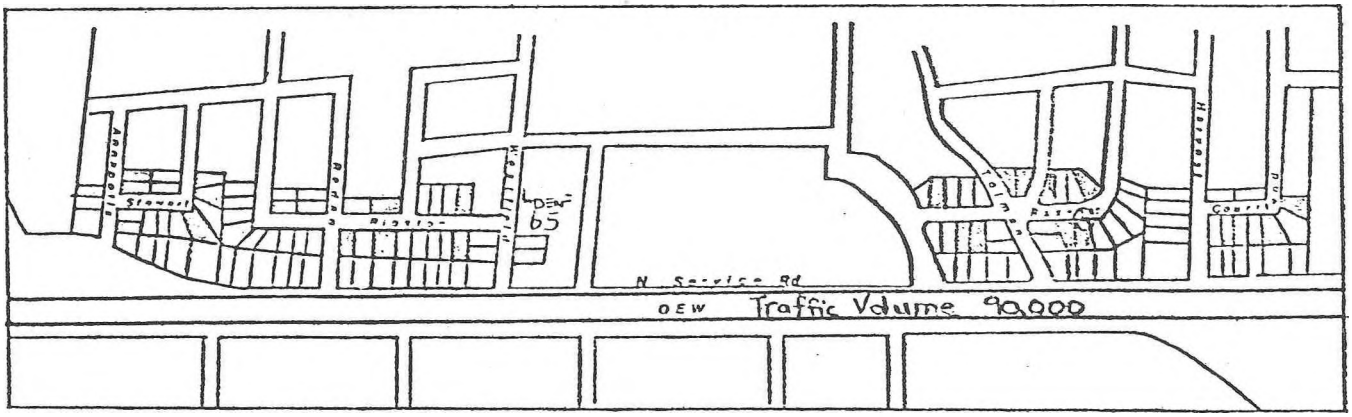

L_{DEN} 65
N Service Rd
OEW
Traffic Volume 90,000

TABLE 1

Site Pairs for Analysis (Sound levels in dBA)

Pair	Location	Type of Shielding	L_{DEN}	Daytime Leq	Evening Leq	Nightime Leq
1	QEW row 2	1 row of housing	65	62	60	57
	Dixie Road	single row of trees	64	61	60	55
2	Stevenharris	several rows of housing	68	67	63	60
	Sterling St.	nothing	68	68	65	60
3	Horizon Village	concrete wall (3.7 m. high)	70	69	63	62
	Garth Street	nothing	69	67	65	61
4	Islington North	single row of trees	76	74	72	67
	Islington South	nothing	76	74	72	67
5	Islington North	single row of trees	76	74	72	67
	Upper James	nothing	77	73	71	70

Variables Used in the Analysis

Source	Variables	Test
Neighbourhood	Attitudes: 1. mention/not mention noise 2. 9-point bipolar scale	 chi-square Mann-Whitney
Main Road, Trucks	A. Attitudes: 1. mention/not mention noise 2. 9-point bipolar scale 3. 10-point unipolar scale	 chi-square Mann-Whitney T-test
	B. Activity Interference: mention/not mention: sleeping relaxing inside/outside conversing inside/outside working inside/outside watching television conversing on the telephone eating	 chi-square
	C. Actions taken: mention/not mention: closing windows using air conditioner staying indoors turning on/up television, radio, records wearing ear plugs waiting for noise to stop individual complaint action organized complaint action	chi-square
	D. Perceived health effects: mention/not mention: nervousness hearing loss irritability headaches interruption of sleep kept awake	 chi-square

TABLE 3

Significance Levels for tests of Association

Pair	Shielding Comparison	Attitudes to Community Noise	
		1. dislike noise (volunteered)	2. overall noise rating
1	a) one row of housing vs. b) tree screen	no difference	.05(a>b)
2	a) several rows of housing vs. b) nothing	no difference	.01(a>b)
3	a) 3.7 m concrete wall vs. b) nothing	no difference	.001(b>a)
4	a) trees vs. b) nothing	.05 (a>b)	no difference
5	a) trees vs. b) nothing	.01(a>b)	no difference

FIGURE 2

Comparative effectiveness of shielding types,

for improving attitudes to overall community noise

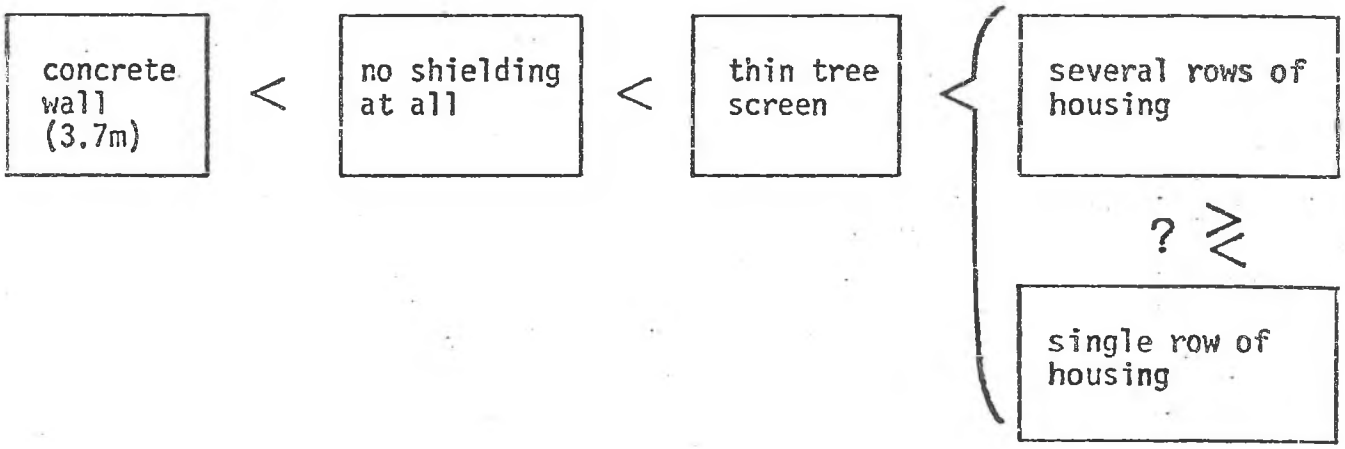


TABLE 4

Significant levels for tests of association

Pair Number	Shielding Comparison	Response to Noise from Main Road			
		Attitudes	Activity Interference	Actions Taken	Health Effects
1	a) one row of housing vs. b) tree screen	no difference	no difference	close window .05(a>b)	interrupt sleep .05(a>b)
2	a) several rows of housing vs. b) nothing	mention road .01(a>b)	no difference	no difference	no differenc
3	a) 3.7m concrete wall vs. b) nothing	no difference	no difference	no difference	no differenc
4	a) trees vs. b) nothing	no difference	relaxing outdoors .05(b>a)	no difference	no differenc
5	a) trees vs. b) nothing	no difference	working inside .05(a>b)	no difference	no differenc